VOLUME 19
NUMBER 2

JOURNAL OF

FEBRUARY
1942

CHEMICAL EDUCATION

Wherever you go, you will find that steel chemists favor Baker's Analyzed C. P. Chemicals, low in Manganese.

Baker's Analyzed Ammonium Persulfate, C. P. Crystal, Potassium Periodate, C. P., and Sodium Bismuthate, C. P. Powder, are all extremely low in Manganese. Not only does the label designate the actual analysis of Manganese, but designates also all other important impurities exactly as found by our analysts.

Think what this label means to the chemist who must operate at top notch speed and *still* be assured of accurate findings.

You may test for Manganese colorimetrically by means of Ammonium Persulfate, Potassium Periodate or Sodium Bismuthate by oxidizing the Manganese in a strong acid solution to Permanganic Acid. Or you may test for Manganese by oxidizing in a Nitric Acid solution to Permanganic Acid, which, in turn, is reduced by either standard Sodium Arsenite or by Ferrous Ammonium Sulfate. In either case Baker's Analyzed C. P. Chemicals save time and are dependable.

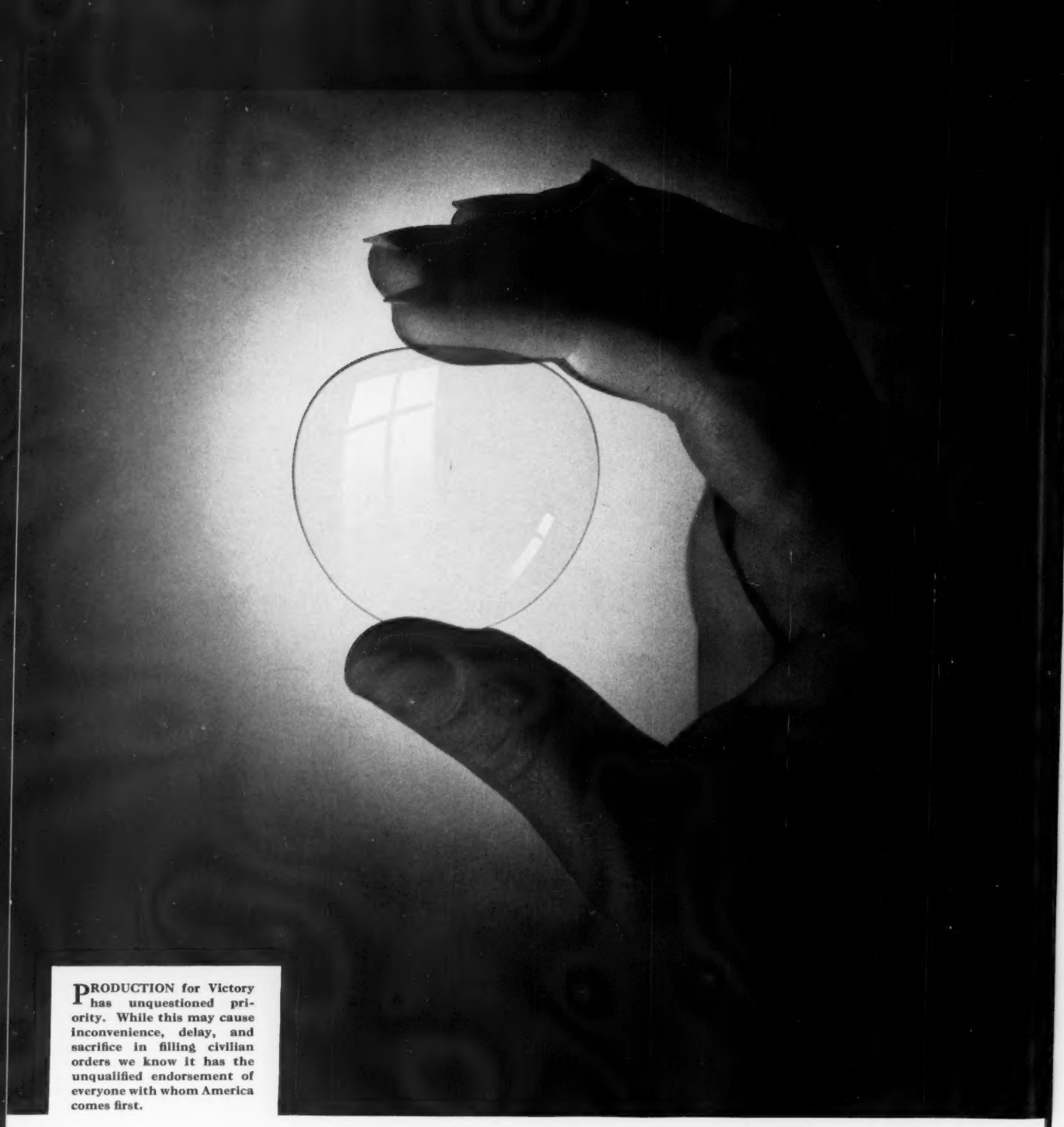
More than 60 well known laboratory supply houses strategically located throughout the country are well stocked and eager to supply you with Baker's Analyzed C. P. Chemicals and Acids. For prompt and efficient service we urge you to get in touch with your favorite supplier.

J. T. Baker Chemical Co. Executive Offices and Plant, Phillipsburg, N.J. Branch Offices: New York, Philadelphia, Chicago.

"Baker's Analyzed"
C. P. CHEMICALS AND ACIDS

Baker's

COLLEGE OF LIBERAL ARTS
LIBRARY



PRODUCTION for Victory has unquestioned priority. While this may cause inconvenience, delay, and sacrifice in filling civilian orders we know it has the unqualified endorsement of everyone with whom America comes first.

Miracle In a Quarter-Ounce of Glass

THIS is an ophthalmic lens, designed for the correction of vision. It measures 43x40 mm, 2 mm thick. It weighs 6.23 grams. Its refractive index is 1.5230, its mean dispersion, 0.00895. Its physical characteristics are matters of scientific fact, but they are no measure of the effect it may have on a human life.

For, through the achievements of modern optical science, imperfect eyes are no longer a handicap. The school child, whose mind might otherwise have been dulled by faulty vision, today faces life undaunted, his eyesight defects corrected. Business men, and housewives, go about their daily affairs with eyes equipped for today's tasks. Older men and women, reaching the age when their eyes can no longer accommodate for vision near and distant, need have no fear of loss of visual efficiency. Modern bifocal lenses, skillfully designed and fitted, restore comfortable youthful vision, extend years of useful working time to aging eyes.

So, in addition to its many contributions of scientific optical instruments for gunfire control, research and industrial production, Bausch & Lomb is filling a vital need as America arms for defense. Workers with properly fitted glasses have vision of top efficiency. That means fewer errors in work, less fatigue, greater production.

BAUSCH & LOMB
OPTICAL CO. • ROCHESTER, NEW YORK
ESTABLISHED 1853

AN AMERICAN SCIENTIFIC INSTITUTION PRODUCING OPTICAL GLASS AND INSTRUMENTS FOR NATIONAL DEFENSE, EDUCATION, RESEARCH, INDUSTRY AND EYESIGHT CORRECTION

Journal of CHEMICAL EDUCATION

OFFICIAL PUBLICATION OF THE DIVISION OF CHEMICAL EDUCATION OF THE AMERICAN CHEMICAL SOCIETY

F. E. Brown, *Chairman* — A. J. Currier, *Vice Chairman* — P. H. Fall, *Secretary* — C. E. White, *Treasurer*

NORRIS W. RAKESTRAW
Editor

Marilyn E. Howe, *Asst. to the Editor*
Harvey F. Mack, *Business Manager*
Cyrus S. Fleck, *Asst. Business Manager*
B. F. Gould, *Advertising Manager*
C. L. Wells, *Circulation Manager*

BOARD OF PUBLICATION

Ross A. Baker, *Chairman*

S. R. Brinkley — P. H. Fall
N. D. Cheronis — F. E. Brown

ASSOCIATE EDITORS

Hubert N. Alyea, Princeton University
Aubison T. Burtsell, College of the City of New York
Tenney L. Davis, Mass. Institute of Technology
Ed. F. Degering, Purdue University
William A. Felsing, University of Texas
Malcolm M. Haring, University of Maryland
Philip A. Leighton, Stanford University
Laurence L. Quill, Ohio State University
Elbert C. Weaver, Bulkeley High School, Hartford, Conn.

BUSINESS & PUBLICATION OFFICES
20th and Northampton Streets
Easton, Pennsylvania

EDITORIAL OFFICE
Metcalf Chemical Laboratory
Brown University, Providence, R. I.

ADVERTISING OFFICE
11 West 42nd Street
New York, N. Y.

VOL. 19 — FEBRUARY, 1942 — NO. 2

Frontispiece—Mural in Science Library, Bryn Mawr College XIII

Editor's Outlook 51

What's Been Going On 52

Christopher Glaser, *Clara de Milt* 53

Government Needs More Scientists 60

The Measurement of Surface Tension: A Laboratory Experiment, *Thomas H. Hazlehurst* 61

Mural in Science Library, Bryn Mawr College (Description) 65

Polarizing Accessories for Microscopes, *C. D. West* 66

The Demonstration of an Induced, or Coupled, Reaction, *James B. Sumner* 70

The Coöperative Committee on Science Teaching 70

Some Useful Expedients in Laboratory Glass Working, *R. H. Wright* 71

Sodium Perborate as a Replacement for Sodium Peroxide in the Chemical Laboratory, *C. F. H. Allen and J. H. Clark* 72

Liebig and Proteins, *Hubert Bradford Vickery* 73

The Ethanolamines, *Chester B. Kremer* 80

Seventy-Five Years of Chemistry at Lehigh University, *R. D. Billinger* 82

Salt This to Taste 85

Objective Test Items of the Recognition Type That Test Reasoning and Minimize Guessing, *Theodore A. Ashford and William M. Shanner* 86

Ten Questions That Students of Chemistry Will Be Asking—and Their Answers .. 90

High-School Chemistry
Modern Uses of Oxygen, *G. O. Carter and H. F. Reinhard* 91

Letters 95

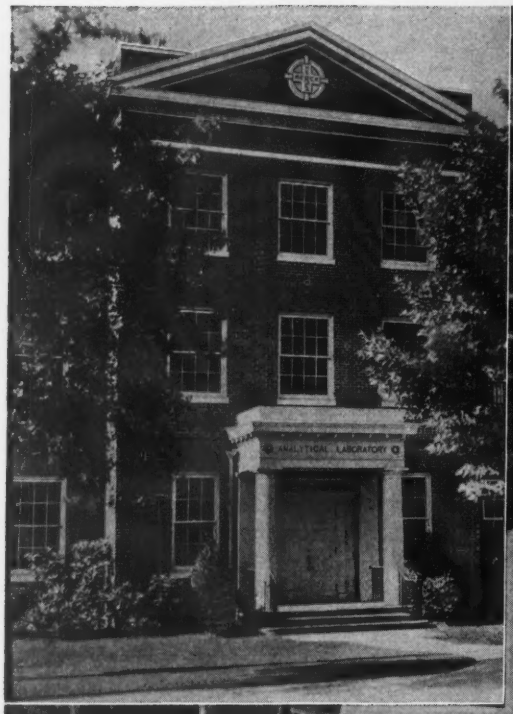
Out of the Editor's Basket 96

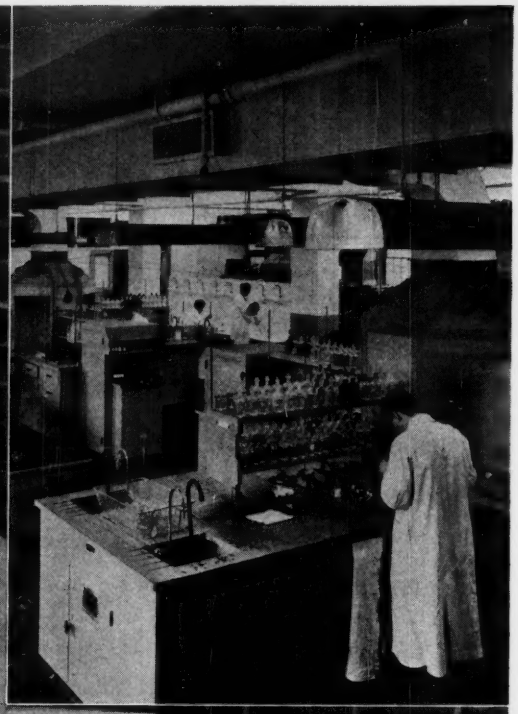
Recent Books 98

Subscription Price: $3.00 per year; Canada $3.50; other countries $4.00. Issued monthly. Single copies of issues in current year, 50c each; all other single copies, one dollar. Foreign remittances must be accompanied by International Money Order.
No claims for copies of journals lost in the mails can be allowed unless such claims are received within sixty (60) days of the date of issue and no claims can be allowed for issues lost as a result of insufficient notice of change of address.
Manuscript for publication should be directed to the editor. Prospective authors are urged to avoid diffuse writing and to observe the forms outlined in our Notice to Authors of Papers as it appears on page XIV of the January, 1942, issue.
Entered as second-class matter, January 31, 1924, at the Post Office at Easton, Pa., under the act of March 3, 1879. Accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 31, 1924.
The JOURNAL OF CHEMICAL EDUCATION *is indexed in the Education Index, Industrial Arts Index, and, in part, in the Quarterly Cumulative Index Medicus*

COPYRIGHT, 1942, BY DIVISION OF CHEMICAL EDUCATION, AMERICAN CHEMICAL SOCIETY

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY





MERCK

A GUARANTY OF QUALITY

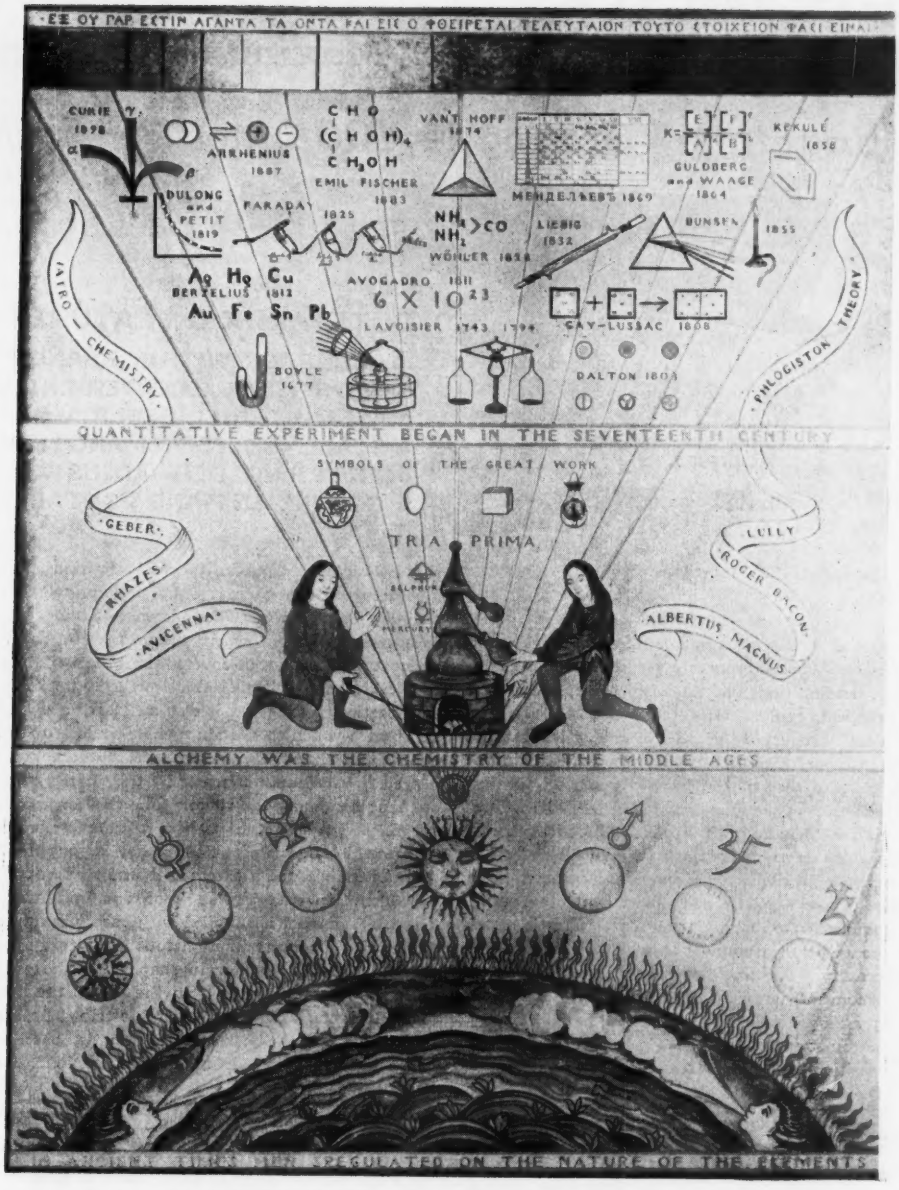
Chemical experience of many years has enabled Merck & Co. Inc. to plan, design and equip the new Merck Analytical Laboratories, wherein rigid and constant control is exercised over more than 1,500 products bearing the Merck label. The wide range of precision, analytical and testing facilities includes not only chemical methods, but physical and optical procedures as well. Because of these modern control facilities, thousands of industrial chemists, students, and research workers use Merck Laboratory Chemicals with complete confidence in their purity and uniformity.

A PLEDGE OF SERVICE

Although the Merck factories are now operating on a 24-hour day, 7-day week schedule in order to supply the needs of our armed forces and civilian population, it may not always be possible to supply you immediately with your complete requirements of Merck Chemicals. But in spite of the difficulties which confront us, we shall continue to do everything possible to serve our customers to the limit of our ability. In facing the vital emergency job that lies ahead, it is our hope that we may continue to have the understanding cooperation of our customers, which has helped us immeasurably in our efforts to serve them.

MERCK & CO. Inc. *Manufacturing Chemists* **RAHWAY, N. J.**

New York • Philadelphia • St. Louis • *In Canada:* MERCK & CO. Ltd., Montreal and Toronto



Mural in Science Library, Bryn Mawr College

(For description of painting, see page 65.)

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

WELCH

SPECTROMETER

R. W. Wood design

Insures
Quicker Observations
Greater Accuracy
Maximum Brilliance

"Brightline" Grating 14,400 Lines Per Inch

No. 3693

OUTSTANDING FEATURES—

- ACCURACY WITHIN 50 ANGSTROMS
- FOUR TIMES GREATER BRILLIANCE
- "BRIGHTLINE" REPLICA GRATING
- SCALE 4000 TO 7600 ANGSTROMS
- FILTER HOLDER—ADJUSTABLE SLIT
- CONVENIENT AND PORTABLE

Through a special arrangement with *Professor R. W. Wood of Johns Hopkins University*, we are pleased to offer exclusively his outstanding design of an inexpensive, yet precise and very practical, replica-grating spectrometer. It is a very convenient instrument for use in many laboratories and in some instances fifteen to twenty are provided in one department to take care of the insistent demand for this useful spectrometer. The replica grating is the "Brightline" type from matrices, made under Professor Wood's personal supervision, which gives four times the brilliance of all other commercially available replicas. The positions of the replica in the eyepiece and of the slit and scale are so arranged as completely to eliminate parallax. This is an exceptionally convenient instrument for a multitude of uses in the laboratory. Spectrometric measurements can be made on a moment's notice with an assured accuracy of less than fifty Angstroms. The mounting is so arranged that the spectrometer can be held in the hand and used in almost any position in the laboratory.

It is available for making quick observations in complicated laboratory set-ups where it would be impractical to set up an ordinary spectrometer; for instance, testing for impurities in a vacuum system, where the presence of some damaging element might not be discovered until the work had continued for several days. This spectrometer is not only available for practical testing but is also an ideal, inexpensive instrument with which to introduce the elementary student to the spectrometer. Brilliant bright-line spectra are easily observed from vacuum tubes or by the ordinary flame method without darkening the room. The relationship of the angle of diffraction and the Angstrom scale is easily explained. A special bracket is provided for holding any desired filter in front of the slit, and a selected cobalt filter is supplied with the instrument for studying the absorption lines in the solar spectrum. A manual is supplied with each instrument outlining and giving diagrams for numerous laboratory applications.

The case is triangular in shape with the greatest width 22 cm and the distance from the slit to the eyepiece is 44 cm. It is mounted on a separable tripod base so that the spectrometer may be removed from the base and held by the convenient handle in any desired position.

No. 3693—SPECTROMETER. Complete with manual outlining and giving diagrams for numerous laboratory applications. . . . . **Each**

LIGHT ATTACHMENT—aluminum casting, with flash-light bulb and battery for dark room use to illuminate scale . . . . . **Each $4.00**

$25.

W. M. WELCH SCIENTIFIC COMPANY

Established 1880

1516 Sedgwick Street **Chicago, Illinois, U. S. A.**

Editor's Outlook

A YEAR or more ago, in the early days of the Selective Service Draft, there was considerable unrest and uncertainty among college students. It was mostly taken out in talk, however, and when the uncertainties resolved themselves—more or less—things settled down into, if not complete equilibrium, at least a metastable state. But now, with actual war finally settled upon us, it is pretty hard to say just what the state of student feeling is.

War brings us face to face with reality, to be sure. And a very real question is: Just how are college students going to fit into this picture—students in general, and of course students of chemistry in particular? In the recent days of "Democracy's Arsenal" we talked in not too vague terms of the necessary part that the chemist must play in the expanding program of production and the necessity of training more chemists as rapidly as possible. In the present A.P.H. (After Pearl Harbor) era all our previous estimates and calculations must be multiplied by a factor of some considerable magnitude.

Already there had been plans to put three million new workers into the "defense" industry in 1942. And now—A.P.H.—nobody knows to what heights this figure will be boosted. We hear it estimated that half our industrial operation will be "war" industry. And we are told that from about five to ten per cent of this new supply of labor must be technically trained—engineers, chemists, and other specialists. Some of these will of course come from other industries, which will have to shut down for the duration, but look at it any way you like, there will be a powerful lot of new places for chemists very shortly.

Already the situation is getting tight. Everywhere one goes he hears: "Have you got a good organic man?" "Do you know where I can get a—?" "You don't happen to know where there's a good—?"

And where *are* we going to get all these men (yes, and perhaps women)? We have some few thousands in training, of course—if we can keep them! But we need more and we need them faster, so they say. The labor division of OPM has told us recently that as far as numbers go we can set our own ceiling, and it will still be too low. They assure us they can use all we can supply, and then some.

Also according to OPM, we are faced with the task of producing the necessary equipment for some 20 million fighting men, our own and those of our allies. One hundred billion dollars have either been appropriated or are in immediate prospect for this purpose; but the *present* plans of industry are based only upon the 39 billions which have been let out in contracts.

Even though at this stage we may become somewhat confused, one clear conclusion seems to stand out: chemists are going to be both important and scarce.

As this goes to press colleges and universities all over the country are rearranging their curricula and calendars so as to telescope four years of college work into three, or less. This is largely the result of a desire to get students through college more quickly and ready for both military and industrial service. We may skip lightly over the merely self-preservative aspects of the movement and stop to consider how the accelerated program affects the training of chemists.

Most institutions seem to be planning a 48-week year, divided into either three or four terms. As a temporary, war-time measure, at least, it seems entirely practical to operate on such a condensed schedule. It will likely be fatiguing to both students and faculty. Some of the desirable features of a more leisurely plan will be lost. But we will turn out chemists more quickly and we must try to maintain the original qualitative specifications of the product as closely as possible. We are entering an era in which the educational emphasis will be changed—alas!—from "opportunity to learn" to "forced instruction." *C'est la guerre.*

We will also make an effort to *increase* as well as accelerate our supply of chemists. Qualified students—with or without invitation—will probably come from other academic fields into this one, when they see in it an attractive opportunity for national service. And a movement is already under way to encourage high-school students who have the necessary interests and abilities to prepare themselves in larger numbers for college training in chemistry, physics, engineering, and other technical fields.

This accelerated college program, at least as it affects the technical fields necessary for war industry, must very likely be subsidized by Federal appropriation. Many, especially state institutions on rigid budgets, will not be able to absorb the extra instructional and operating costs. And, more important, many students will not be able to sacrifice the summer vacations upon which they depend for income. A system of Federal scholarships or loans may be necessary.

Over all this training program, however, based as it is upon a sound and recognized need for technical specialists, hovers the specter of Selective Service. Until this is divested of its fearsome uncertainty all the rest will be only partly effective. All the struggle to train fifty per cent more chemists in thirty per cent less time is of no avail if any large proportion of them are then drafted into military service. We can't really believe that such a calamity will happen, but it is just as bad if students think it *may* happen. We can provide courses but students are after all free to come or not as they like. Every potential chemist who decides to enlist in the navy, because he doesn't want to be drafted into the army, is a loss to the country. There are plenty of naval recruits and few potential chemists.

Students are thinking about these things, and on page 90 we have collected some of the questions in their minds—and their answers. (Reprints of these may be had free in any reasonable number.)

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

What's Been Going On

NINETY-SIX per cent of the natural rubber used in the United States comes (came!) from the Far East.

The per capita use of rubber in the United States is (was!) 10.5 pounds per year.

It is estimated that the supply of scrap rubber available is about twice that reclaimed annually. Thanks to manufacturers who have kept reclaiming processes up to date, we now reclaim tonnage equivalent to about one-third of our annual consumption of natural rubber.

The annual production of latex from two or three rubber trees is required for the average tire containing about 10 pounds of rubber.

The Defense Plant Corporation is to finance, build, and control two new plants for the production of chemicals for synthetic rubber. Carbide and Carbon Chemicals Corporation, Charleston, West Virginia, will operate one of these in the production of butadiene, and Monsanto Chemicals Company will operate the other, to be built at Galveston, Texas, to produce other necessary intermediates in the synthesis of rubber.

Ameripol soles and heels are now in production, according to the B. F. Goodrich Company of Akron, Ohio. Ameripol is particularly resistant to oils, greases, gasoline, and naphtha.

Tires with a million times the conductivity of ordinary tires have been designed for trucks, so as to eliminate spark hazards from the accumulation of static electricity.

Breathlessness, fainting spells, fatigue, and disturbance of pulse rate, somewhat common in British soldiers, may be attributed to lack of pantothenic acid, according to studies conducted by G. C. Supplee of the biological and chemical laboratories of the Borden Company.

The Ford upholstery engineers have developed a latex-sprayed cactus fiber "which will not become matted, will keep its set and resiliency throughout the life of a car, and will remain extremely tough and strong."

It is estimated that the use of plastic eraser holders on pencils will release about 150,000 pounds of metal for other purposes.

Chlorine, one of the defense materials, may now be produced in almost unlimited amounts by treating sodium chloride with sulfur trioxide and subjecting the mixture to fusion. The products of the reaction are chlorine, sodium sulfate, and sulfur dioxide, the reaction being:

$$2NaCl + 2SO_3 \text{ (above 330°C.)} \rightarrow Cl_2 + Na_2SO_4 + SO_2$$

The sulfur trioxide is obtained by burning sulfur, which is an exothermic reaction; hence the heat required for the fusion of the mixture may be obtained in part at least from the heat of the reaction. The process has been developed by A. W. Hixon and A. H. Tenney, of Columbia University.

Copper, like iron, is reported to be a constituent of all plant and animal tissues. Fortunately, however, copper deficiency severe enough to produce nutritional anemia is rarely found in adult human beings.

That the spider is making its contribution to our war preparations is evidenced by one phase of the work of Mrs. Nan Songer, who is the manager of an industry in Southern California. Spider webs are extracted from their producers for use in the manufacture of camera view finders, range finders, surveying instruments, and target sights.

The Institute of Biochemistry at Moscow, Russia, reports that the soft outer shell of unripe walnuts may be extracted, treated to remove the bitter taste, and the resulting solution evaporated to give a concentrate of vitamin C.

The total installed and planned production capacity for magnesium now amounts to 400,000,000 pounds per year.

Sodium vapor lighting may be utilized in homes and offices and factories, during blackouts, if the windows are painted blue. This permits ample interior lighting during the day.

Concentrates of vitamin B_1, according to P. R. Burkholder, of Yale University, have been found in the buds of elm, horse chestnut, oak, red maple, sycamore, and white pine trees. "This finding may offer a clue to the source of essential vitamins for many forest animals."

One hundred pounds of sawdust may be used as the raw material for the production of about eight dollars worth of vital chemicals, such as methanol, acetic acid, formic acid, and oxalic acid.

Saran tubing is now available to industry as a substitute for certain uses of copper and other metal tubing.

Thick lubricating oils may be made from animal, fish, or vegetable oils, by passing the oils over boron fluoride.

An 18-foot torpedo carries 11 cubic feet of air under a pressure of 2259 pounds per square inch, and 2 gallons of alcohol and 4 gallons of fresh water for the generation of steam. This three-quarter ton weapon will travel a distance of 3000 yards at about 40 miles per hour. Its power in the water is the equivalent of a modern V-8 automobile engine, and its cost is about $10,000.

—Ed. F. Degering

DURING the last week of December, the Division of Physical and Inorganic Chemistry held its sixth annual symposium in Columbus, Ohio, on the topic, "Recent Developments in the Chemistry of the Non-Metals." Some of the topics discussed were:

Sulfur dioxide recovery from dilute smelter gases is practiced to reduce the destruction of vegetation in the region of the plant. Economical methods of converting the SO_2 to useful products are now practiced, at a cost comparable with that based on pure SO_2 from Texas sulfur. Large quantities of free sulfur are produced from waste gases by reduction of the SO_2 by means of hot coke, and by catalytic reduction with natural gas SO_2 is converted to CS_2, and carbonyl sulfide, COS. Use of liquid SO_2 as a selective extraction fluid, for processing petroleum and vegetable oil products, was described.

Sulfamic acid, HSO_3NH_2, has become available in large tonnage in the last four years and has many industrial applications. It is prepared by treating urea with oleum and is an inexpensive, non-hydroscopic, non-toxic, crystalline acid which is nearly as highly dissociated in water solutions as sulfuric or phosphoric acid. The acid has advantages in nitrite removal in diazotization reactions, in tanning leather, and in laundry sours. The salt, ammonium sulfamate, is one of the most effective weed killers and has wide application in the removal of poison ivy in orchards. It is free from fire hazards, attendant upon the use of chlorates, and leaves a residue in the soil which serves as a fertilizer. One pound of $NH_4SO_3NH_2$ in a gallon of water is sufficient for 100 square feet, and should be applied in the summer and early fall. When sprayed on the leaves of poison ivy or wild cherry, it kills the entire plant, but poisons the surrounding soil for only a very short period.

A second important application of $NH_4SO_3NH_2$ is in flameproofing fabrics and paper, with no alterations of the surface characteristics.

Pure crystalline sulfamic acid is a highly satisfactory standard for acidimetry. When sulfamic acid is used in electroplating baths, a smoother plate results.

A million pounds of selenium and two hundred thousand pounds of tellurium are produced annually in the electrochemical purification of copper blister. The modern photographic exposure meter is an improved selenium type photoelectric cell, and selenium finds extensive use in rectifiers. Rubber containing 2 per cent of tellurium has superior abrasion-resisting characteristics and finds use, for example, in coating arc-welding cables. Stainless steels containing 0.1 or 0.2 per cent of selenium or tellurium are free-machining. Magnesium alloys are protected from corrosion by means of elementary selenium and the coating serves as a bond for paints as well. Large quantities of selenium are used in producing ruby-colored and black glass. The familiar

(*Continued on page 79.*)

Christopher Glaser[1]

CLARA DE MILT

H. Sophie Newcomb Memorial College, Tulane University, New Orleans, Louisiana

THE name of Christopher Glaser is perpetuated in old books on chemistry and pharmacy in the term Glaser's salt, impure potassium sulfate, which he first prepared by the heating of a fused mixture of niter and sulfur, and in the name of the mineral glaserite, naturally occurring crystalline potassium sulfate. He should be remembered also as the author of the first simple textbook of laboratory preparations in chemistry—the first book on chemistry in which substances are discussed from the standpoint of their source and chemical relationships as mineral, vegetable, and animal substances. This credit has been universally accorded to Nicolas Lemery.

Little is known of Glaser's life. He was a native of Basel, Switzerland, where he took degrees in pharmacy and medicine. This fact gives us certain information as to his training, as the statutes of the University of Basel from laws passed in 1570 required that the candidate for the medical degree must have had adequate previous schooling; must have spent, between the ages of twenty-one and twenty-eight, five years at a university (studium); and must have a good reputation and honorable birth (*1*). Several years before he was appointed to the post of demonstrator in chemistry at Le Jardin du Roi (*2*) in Paris Glaser must have opened a shop and laboratory, "la Rose Rouge," in the faubourg St. Germain, Rue du Petit Lyon. As his book shows, his interest was primarily in mineral preparations and he could have undertaken such a venture only under the protection of one or more important officials of the time, for edicts dating from January, 1551, on had denied to all persons, physicians, and others, the right to operate furnaces and carry on operations with metals without the permission of the king, verified by the civil authorities (*3*). The government officials, however, were interested in all practical work relating to mines and minerals and encouraged experimentation of this kind so that the granting of such permission was the rule rather than the exception. Glaser, in discussing mercury, speaks of having seen a mine of "Vif Argent" near a village while he was traveling from Gorits, a town in Esclavonie, to Lubiane, capital city of Carniolle. He writes further of the mines in Hungary and Transylvania, so he may have been urged to settle in Paris by reason of his first-hand knowledge of minerals. But it is more probable that Fagon, sent by Vallot to the botanical gardens of Europe in 1658 to search for rare plants for the garden in Paris, was responsible for Glaser's establishment in Paris. Basel, at this time, was a great center for the study of pharmacy; its professors, many of whom had studied at Montpelier, were interested in the new mineral remedies. There was also an excellent garden of simples connected with the Medical School of the University. That Glaser owed his success to Vallot cannot be questioned. In the preface to the first edition of his small treatise (1663), he speaks of having been chosen by Vallot to give lectures and show chemical operations in public in the royal garden. The second edition (1667) is dedicated to Vallot:

"Monsieur,

"Some time ago I published a short treatise of chemistry for the convenience of those who attend the lectures which I give every year by your order at Le Jardin du Roi; at that time it was my intention to offer it to you but after comparing the meagerness of my book with what I owe you, I felt that I should not have the audacity to dedicate a book, which explains confusedly and with crude expressions the mysteries of chemistry, to one who possesses especial insight into this wonderful art and who sees clearly into the deepest secrets of Nature; however, as I must recognize in some manner the favors which you have showered upon me, I do believe that my lack of merit should not outweigh my zeal and I have felt that it would be preferable to offer you this second edition, rather than to appear ungrateful and neglectful. I have added some experiments, enriched it with new discoveries which I have made since the printing of the first edition; and as the public has found it somewhat useful, I feel that the reader should know that your liberality has made this edition possible. I beg of you, very humbly, Monsieur, to receive it as a testimonial of my gratitude and as a proof of my desire to show myself worthy of the post with which you have honored me and as a sign of the humility with which I am,

Monsieur,
Your very humble and obedient servant,
C. GLASER."

Glaser was demonstrator at the garden for at least eleven years, during which time he continued to operate his pharmacy and laboratory which he had now established in Rue Neufue des Fossez, still retaining the name "la Rose Rouge." Early in September, 1672, he became implicated in the most famous poison case of the time, that of la Marquise de Brinvilliers, who poisoned her father and her two brothers with white arsenic. There are many stories current as to what became of him after the affair became public. The third edition of the treatise was published in 1673. It contains a letter from the printer to the reader which states that the revision and correction by the author of Section Three of Book Two, the chapters on animal substances, were not possible because of his death. The approbation of the Faculty of Medicine of the University of Paris is dated October 25, 1672. However, Professor Häfliger, Professor of Pharmacy at the University of

[1] Presented in part before the Division of the History of Chemistry at the 101st meeting of the A. C. S., St. Louis, Missouri, April 9, 1941.

The name appears as "Christophle" Glaser on the title pages of the French editions of his book. The "Christophle" of seventeenth century French became "Christophe" in modern French and this is the form used in the "Bibliothèque Nationale Catalogue Général," Paris, 1915, Vol. 61. The German form of the name is "Christoph."

Basel, has stated that Glaser returned to Basel where he practiced medicine, chiefly surgery, until his death in 1678. Glaser married a widow, Dorothea Werenfels, née Burckhardt. He had no children.[2]

The first edition of "Traité de la Chymie" by Glaser is referred to by Ferguson as a handsome octavo volume (*4*). There is a copy in the Library of the College of Physicians in Philadelphia and W. B. McDaniel, 2nd, the librarian, considers it a good specimen of contemporary printing. In this copy the publisher-author's notice on the title page is a printed cutting pasted over the original notice. There is no dedication. The preface, reprinted with but few changes in the second and the fourth editions but not included in the third Paris edition printed after Glaser's departure, is interesting since it not only indicates the general character of the book but also of the man. Here is no flatterer. In discussing the purposes of writers on chemistry he says:

"Finally. Others which deserve not the name of Chymists, but rather of ignorant Blowfires, working by copied or stolen Receipts, . . . have made many others accompany them in their fortunes, engaging the vulgar by promises of enriching them in certain practices, whereby they have reduced the best Metal into Smoak, unless perhaps they past some part of it through their own hand, which is not the least of their Operations. . . . . As for myself, who profess to say nothing but what I know, and to write nothing but what I have done, I purpose only in this little Treatise, to publish a short and easy method for the happy attainment of all the most necessary preparations of Chymistry."[3]

The preface is followed by a "Table des Matières." Book One, consisting of sixty pages divided into ten chapters, takes up

"what seemed necessary concerning the Names, Usefulness, and Definition of Chymistry; as also concerning its Object, Matter and Functions. We have also spoken of its Principles and the several operations whereby the same may be separated and purified. We have likewise described the Figures of Vessels and their Variety; the construction and matter of Furnaces, the diversity of Lutings (as defined elsewhere in the book, materials as fat Earth, or Potters-clay commonly called Cement); and lastly, the manner of giving and graduating Fire; without the action whereof, all the rest would be useless. These Generals will not perplex the mind, and yet they will afford a Theory sufficient for Practice; to which we shall now proceed." (Pages 47–8 of the English edition.)

In Book One there are two double-page engravings, one of apparatus and one of furnaces, which are to be found in the other editions and also in the translations. Book Two is divided into three sections: Section I of 213 pages divided into 21 chapters deals with mineral substances; Section II of 182 pages divided into 24 chapters is on substances of vegetable origin; Section III of 22 pages divided into eight chapters is on substances of animal origin. Book Two begins with an introduction and in the last paragraph of this introduction the author explains the divisions of the book into three sections:

"This second part shall be divided into three Sections. The First shall treat of the Preparations of Metals, Metallick Bodies, Stones, Vitriols, Salts, etc. The Second shall teach the Preparation of Vegetables. And the Third that of Animals; to which we shall join some Preparations of things not comprehended in these three Families, as Manna, Honey, Wax, etc." (Page 54.)

The first edition contains the three preparations original, so far as I can discover, with Glaser: that of "pierre infernale ou caustique perpetuel" (fused silver nitrate sticks), "magistere du bismuth" (bismuth oxynitrate), and "sel polychreste" (potassium sulfate). The quotation in part of the preparation of "pierre infernale" will illustrate how clearly and concisely he describes chemical processes.

"Take two ounces of Cuppled Silver; . . . dissolve it in a Matrace with its double or triple of good Aqua-fortis; pour the Solution into a Gourd covered with its Alimbeck . . . ; evaporate it . . . . Leave the Vessel some hours to cool, and you shall find the matter remaining in the bottom in the form of a Salt, which put into a good German Crucible somewhat large, because the matter swells at first in boiling, and would be apt to run over and be lost. Set the Crucible upon a little fire, till the Ebullitions be passed, and the matter be fallen to the bottom; about which time augment the fire a little, and you shall see the matter like Oil in the bottom of the Crucible. Pour it into a very clean Casting-mould a little heated before, and you shall find it as hard as Stone; keep it in a Box for use. But for greater convenience, to the end the Surgeon may have pieces of several sizes to employ in hollow Ulcers, of the bigness of the Tag of a Point, or other Figure according to occasion cut the matter before it be quite cold, and leave it in such figures as you think fit."

Then there follows a paragraph on its uses. In another paragraph,

"The daily use of the said Remedy will discover, will shew its excellency in sundry other Diseases. 'Tis prudence in a Surgeon to use oftentimes the same Medicament for different Maladies, when the Indications concur. This Stone is very commodious and lasts very long. 'Tis called Infernalis, partly from its black colour, and partly from its Caustic burning quality.

"Observe, that the virtue of this stone proceeds from the Corrosive Salts of the Aqua-fortis which the Silver congeals and retains. You may make the like Stone of Copper or Iron the same way saving that Iron and Copper reduced into this condition attract the Air more powerfully, and dissolve into Liquor: which happens not to this of Silver, for it preserves itself always in solid form." (Pages 74–6.)

If the reader compares this account of the preparation with that given in Chapter II of any of the early editions of Lemery's "Cours de Chymie," he will discover how closely Lemery followed the procedure of Glaser, even using the same phrases in describing the operations and in commenting on the product.

Glaser was a careful observer and the details of most of the directions show that he paid due regard to quantities of materials used and to quantity of product

---

[2] This information was given in a letter from Professor Häfliger, dated March 10, 1941. Professor Häfliger has included a biography of Glaser in his "Biographikon."

[3] GLASER, "Traité de la chymie," Chez l'Autheur, Paris, 1668. Since there are almost no variations in the wording of the editions of Glaser's book, most of the English translations quoted in this article have been taken from "The Compleat Chymist" by Christopher Glaser, faithfully Englished by a Fellow of the Royal Society and published in London in 1677. This is a translation of the fourth French edition. According to Peter Shaw the translation was made by Walter Harris, M.D. There is a copy in the Harvard Library.

obtained. This may also be said of his disciple Lemery. In describing the calcination of lead Glaser notes,

"The Calx of a Pound of Lead will be found encreased above two ounces, by reason of the Particles of Fire incorporated with it, and by their activity reducing it into very subtle parts. This augmentation is also observed in the Calcination of Tin and other imperfect Metals." (Page 79.)

He had no sympathy with the alchemists of his time who believed in the transmutation of the metals and who spent much of their time searching for the universal solvent. This is indicated in the introduction to Book Two,

"By these Examples of common Sulphur, Lead and Antimony, 'tis easy to understand, that the more compact or perfect a Metal is, the more it ought to be opened and disposed to the separation of its superficial Sulphur; I speak not of that which is internal and essential, since we believe Metals indivisible; unless any man will pretend to reduce them into their Principles, or several substances by the Alkahest or universal Dissolvent, of which I shall not discourse here, for fear of offending some, who think they possess it, and yet have not even good particular Dissolvents, or being esteemed too incredulous by those that seek it. If we should say that 'tis hard to imagine how a Liquor without Corrosion can resolve all Sublunary Bodies into their true Principles, without any reaction on their part; and how this Dissolvent should diminish neither in weight nor vertue, but have as much strength after a thousand Dissolutions, as in the first; as Van Helmont discourses of it. Wherefore wanting this mystery, we maintain, that whatsoever form is given to Metals by the ordinary Dissolutions, which are properly Corrosions; they remain always reducible into their first substance, with little or no alteration." (Page 50.)

Van Helmont is the only contemporary writer referred to by Glaser. He is spoken of twice and both times the remarks are criticisms of his theory. Glaser, however, must have been conversant with most of the treatises on chemistry of his time and certainly with the works of Glauber and Le Fevre or Le Fevre's sources. In the remarks on the preparation of Mineral crystal or Sal Prunellae, purified saltpeter heated with a small quantity of sulfur, he says,

"Some make use of purified Salt-peter without preparing it with Sulphur; which I disapprove not, because the Sulphur carries away with it part of the Sulphureous Volatile Salt of the Salt-peter, and so deprives it of some of the purest part of itself." (Page 157.)

This same idea is to be found in Lemery's book, expressed in about three times as many words (*5*). Glaser's skepticism of the claims of some of the writers of his day can be illustrated by his remarks on tincture of coral,

"Many have imagined that they knew how to draw the Tincture of Coral, and almost all authors have given us thereof preparations as true as Esop's Fables. For many would draw this Tincture with Spirit of Oak Wood—of Guiacum, etc."

The paragraph ends with a remark, repeated over and over again in the book,

"And as I pretend not to put any Preparation in this little Treatise, of which I have not made trial with my own hands, I will here give forth my manner of a Tincture of Coral, which seemes to me reasonable and true." (Pages 192-3.)

Glaser's main interest was, without doubt, the preparation of chemical medicines but every now and then he includes odds and ends of practical value, always apologizing for the addition. At the end of the discussion of "A Diaphoretick Powder of Gold" prepared by dissolving gold in aqua regia, adding refined saltpeter to the solution, and igniting linen moistened with this liquor, he says,

"This Powder hath been in some hands as a great secret; and they have told wonders of it to the credulous, who are easily taken with the least things. If you rub Silver with this Powder moistened with a little water, it guilds it very well and this guilding is of long continuance." (Page 68.)

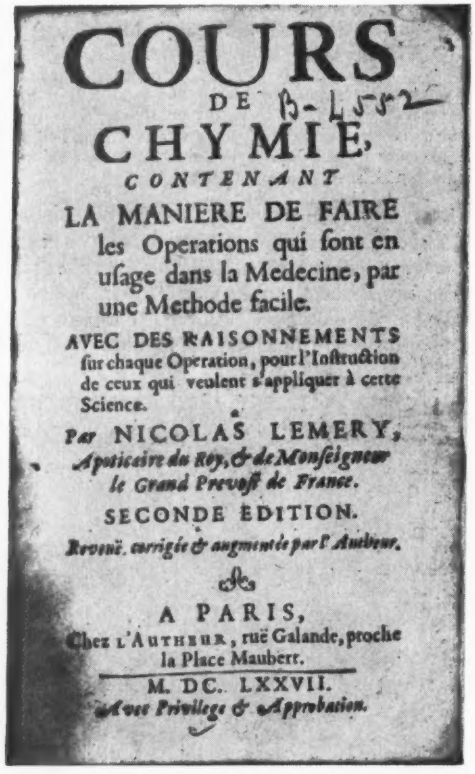
The second edition (1668), also an octavo volume of 394 pages, is very like the first in spite of the statement in the dedication to Vallot. There was added a third figure showing furnaces and distilling apparatus in operation. Book Two, Section I, contains an additional chapter, "Of the Mineral Cinnabar." The third

Courtesy of the Tulane Library

TITLE PAGE OF THE SECOND EDITION OF GLASER'S TREATISE

edition (1673), published after Glaser had left Paris, is a 12mo volume, substantially a reprint of the second edition except for Section III on animal substances, to which additions had been made—additions that most certainly would never have been written or approved by Glaser. In this edition there is a communication

from the printer to the reader in which he says that the section on animal substances has been written in most finished form either by use of information found in the papers of the author after his death or by the fortunate


COURS
DE
CHYMIE,
CONTENANT
LA MANIERE DE FAIRE
les Operations qui ſont en uſage dans la Medecine, par une Methode facile.
AVEC DES RAISONNEMENTS ſur chaque Operation, pour l'Inſtruction de ceux qui veulent s'appliquer à cette Science.
Par NICOLAS LEMERY,
Apoticaire du Roy, & de Monſeigneur le Grand Prevoſt de France.
SECONDE EDITION.
Reveuë, corrigée & augmentée par l'Auteur.
A PARIS,
Chez L'AUTHEUR, ruë Galande, proche la Place Maubert.
M. DC. LXXVII.
Avec Privilege & Approbation.

Courtesy of the Lloyd Library in Cincinnati

TITLE PAGE OF THE SECOND EDITION OF LEMERY'S "COURS DE CHYMIE"

help of one profoundly versed in medicine and well disposed toward the public who has been willing to spare some hours from study in order to dictate the larger part that is found added to this treatise: the part concerning the viper and that describing "une Theriaque Royale." The physician referred to by the printer was most probably Antoine d'Aquin, nephew of Vallot by marriage, who succeeded Vallot as first physician of Louis XIV. "La Theriaque Royale" reformed by Monsieur d'Aquin had been popularized in Paris by Moïse Charas, the first edition of whose treatise on this remarkable remedy appeared in Paris in 1668. At the time that this third French edition of Glaser's book came out, Charas was demonstrator in chemistry at Le Jardin du Roi. There may have been another edition published in Paris in 1688. It is not recorded in the "Bibliothèque Nationale Catalogue Général," but is found in the account of Glaser in the "Nouvelle Biographie Générale" and is mentioned in other references. There were three editions published in Lyon: 1670, 1676, 1679. The French edition published in Brussels in 1676 is referred to as the fourth edition and it was from this that the English translation was made in 1677. A comparison of the English translation of this fourth French edition with the second Paris edition shows that it is really a reprint of the second edition. It was translated into German and published in Nürnberg in 1677 with the title, "*Novum Laboratorium Medico-Chymicum.*" Another German translation was published in Jena, in 1677, under the title "Chemischer Wegweiser" which was reprinted in 1684, 1696, and again in 1710.

Despite the fact, however, that eight editions of "Traité de la Chymie" were published in French, one in English, and five in German, historians of chemistry and medicine have, with few exceptions, neglected, even disparaged the work of this man. Boerhaave in the section of his great text devoted to the history of chemistry recognizes Glaser as a "systematical writer" and classes him with Beguin, Le Fevre, and Lemery; Peter Shaw remarks in the notes to his translation of Boerhaave's book (*6*),

> "His (Glaser's) book is candidly and clearly wrote, and contains a little system of chemical processes for making chemical medicines in an easy and effectual way. He keeps close to the describing of such operations as himself had frequently repeated, without intermixing any foreign theory. The book is short and fit for beginners."

Hoefer, besides noting that it was from this able chemist that Nicolas Lemery absorbed some good principles of manipulation, says that Glaser appreciated the great importance of details in the practice of chemistry and that the preparations are described with rare simplicity (*7*). Bouvet names Glaser with Le Fevre and Rouelle as among the most important who lectured at Le Jardin des Plantes and speaks of his "beautiful discoveries" (*8*). But these are the exceptions. Kopp does not refer to him in his history of chemistry and Lippmann in his recently published history of bismuth omits any mention of his name and credits Lemery with the discovery of bismuth oxynitrate (*9*).

Three errors appear constantly in histories of chemistry and in biographies of chemists of this period: namely, that Lemery was the first writer of the period who treated of substances on the basis of their origin and classified them into mineral, vegetable, and animal substances; that Glaser was an obscure writer and a blind follower of Paracelsus; that Nicolas Lemery succeeded Glaser as demonstrator at Le Jardin du Roi. One can account for these misstatements only on the basis of total disregard or ignorance of the texts of Glaser and of the early texts of Lemery and lack of knowledge of the life and work of Lemery. So far as the writer has been able to discover, Hoefer alone recognizes that Lemery learned the greatest part of his procedures from Glaser, though one can surmise that this also was the opinion of Ferguson, who read a paper on Glaser before the Philosophical Society of Glasgow in 1901. The misunderstanding of the importance of Glaser's contributions to the development of chemistry and of the debt Lemery owed him seems to have origi-

nated from the Éloge of Lemery written by Fontenelle. According to the account of Fontenelle Lemery left Rouen in 1666 and went to Paris, where he lived with Glaser in order that he might take advantage of a good source of experiments and analyses. But it happened unfortunately that Glaser was a true chemist (that is, not a man of science) full of obscure ideas, miserly even of these ideas, and but slightly inclined toward sociability. Lemery therefore left at the end of two months.[4]

Furthermore Dumas has emphasized this poor estimate of the worth of Glaser (*10*).

"Nicolas Le Fevre was replaced at Le Jardin des Plantes by a man . . . much inferior to Le Fevre . . . a man who was never able to rise above generalities . . . . Glaser has added nothing to the theories of Le Fevre . . . . For him chemistry . . . is the art of resolving mixtures by an infinity of operations . . . . Bon Dieu, quelle Chimie!"

As an illustration of the contents of Glaser's book Dumas selects Chapter VI of Book One in which the designations of operations used in chemistry are first listed and then defined. Glaser defines thirty operations, arranging the definitions in alphabetical order. In the second edition of "Cours de Chymie," in the first portion of the book which corresponds to Book One of Glaser's treatise, Lemery defines fifteen operations, omitting some of the more important of those included by Glaser. For example "to extract" and "to crystallize" are omitted. The definition of "to crystallize" shows that it means to purify by recrystallization. Glaser defines "to extract" as follows:

"To Extract, is to separate in Animals and Vegetables the purest parts from the most gross, by fit menstruums that are proper for the extracting of those substances which the Artist desires: as for example, we extract the rosinous substance of Jalap by Spirit of Wine, because that the rosin is the sulphureous part of the Jalap; and that Spirit of Wine does likewise contain a subtil Sulphur, which easily unites with the other. So in all Extractions the Artist must have a regard to find out a menstruum fitted to the substances he desires to extract." (Page 14.)

Lemery must have realized somewhat later that he had omitted too many of the operations included in his model, for in the fourth edition the number of operations defined has increased to twenty-seven and most of those given by Glaser have been included (*11*). One can easily explain the error of Dumas. Jean Baptiste Dumas delivered the "Lectures on Chemical Philosophy" during the summer of 1836, which is within the period of his greatest experimental work. Dumas wrote and spoke with emphasis and enthusiasm and very often such gifted chemists do not feel that it is necessary to pursue the details of a literary subject. Dumas had, without doubt, glanced over a copy of Glaser; the chapter on operations attracted his notice; he turned the page to see before him fifty operations of chemistry listed as fifty verbs in no particular order! He closed the book and having read the Éloge of Fontenelle, he proceeded with the writing of the lecture on this period. But what can be said of Fontenelle's remarks? Nothing. It is to be hoped that he did not get his information from Nicolas Lemery. It is the opinion of the writer that Lemery worked as an apprentice in the pharmacy of Glaser for at least three years and that Glaser urged him to go to Montpelier for further study. Glaser had been associated in Basel with pharmacists and physicians trained at Montpelier and its reputation in pharmacy at this time was the best in France. Lemery returned to Paris in 1672. When in 1672? Was he in Paris when misfortune overtook his former master apothecary?

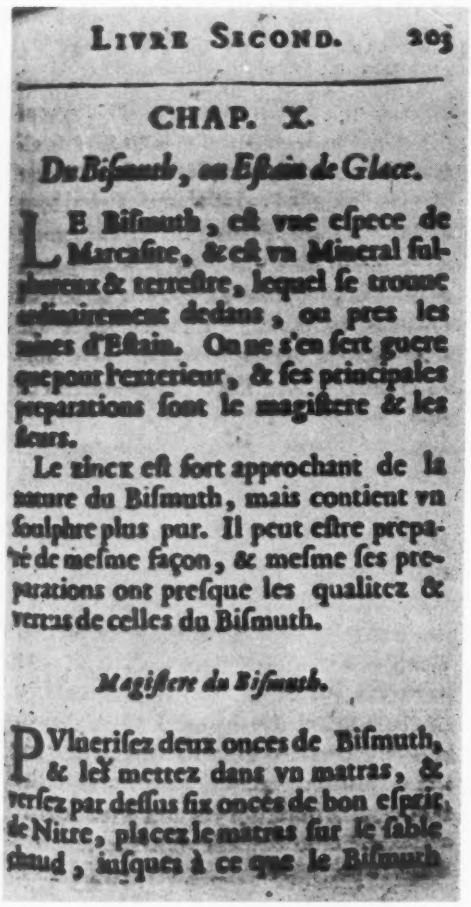
A comparison of any of the editions of Glaser's little treatise with the second edition of Lemery's "Cours de Chymie" (1677), the earliest edition that the writer has been able to locate in this country, will show the great similarity of the two books and will point to the conclusion that the model of the now famous "Cours de Chymie" was the "Traité de la Chymie" of Christopher

Courtesy of the Edgar Fahs Smith Memorial Collection, University of Pennsylvania

FRONTISPIECE OF THE 1720 ENGLISH EDITION OF LEMERY'S "COURS DE CHYMIE"

[4] FONTENELLE, "Oeuvres de Fontenelle," Bastien, Servieres, Paris, 1790, Vol. 6, p. 369. This passage is quoted in all accounts of Glaser to his detriment. It might be well to quote the original. "Il s'adressa à Glaser, alors démonstrateur de chymie au jardin du Roi, et se mit en pension chez lui pour être à une bonne source d'experiences et d'analyses. Mais il se trouva malheuresement que Glaser étoit un vrai chymiste, plein d'idées obscures, avare de ces idées-la-mêmes, et très-peu sociable. Lemery le quitta donc au bout de deux mois . . . ."

Glaser. There is a copy of the second edition of Lemery's book in the Lloyd Library in Cincinnati. The second edition of Glaser's text is an octavo volume of 394 pages divided into two books. Following the title pages, the simple dedication to Vallot, and the



LIVRE SECOND. 203

CHAP. X.

Du Biſmuth, ou Eſtain de Glace.

LE Biſmuth, eſt vne eſpece de Marcaſite, & eſt vn Mineral ſulphureux & terreſtre, lequel ſe trouue ordinairement dedans, ou pres les mines d'Eſtain. On ne s'en ſert guere que pour l'exterieur, & ſes principales preparations ſont le magiſtere & les fleurs.

Le zinck eſt fort approchant de la nature du Biſmuth, mais contient vn ſoulphre plus pur. Il peut eſtre preparé de meſme façon, & meſme ſes preparations ont preſque les qualitez & vertus de celles du Biſmuth.

Magiſtere du Biſmuth.

PVluerizez deux onces de Biſmuth, & les mettez dans vn matras, & verſez par deſſus ſix onces de bon eſprit de Nitre, placez le matras ſur le ſable chaud, iuſques à ce que le Biſmuth

Courtesy of the Tulane Library

BEGINNING OF CHAPTER ON BISMUTH FROM THE SECOND EDITION OF GLASER'S TREATISE

table of contents, there is a short preface which has already been discussed in some detail in this paper. Book One, of 64 pages, contains ten pages of theory, the rest being devoted to the operations of chemistry. The second book is divided into three sections. Section I of 207 pages is on mineral preparations, each chapter including several of these. At the end of each preparation there is a short paragraph, sometimes only a few sentences, on the use of the product in medicine, if the substance is so used. Section II of 103 pages is on substances prepared from plants. Section III of 22 pages is on substances of animal origin. An examination of the second edition of Lemery's text shows that it is also an octavo volume of 580 pages. The title page shows that the author is an ordinary apothecary to the king and is selling the book himself at his shop in the faubourg St. Germain. Lemery was a disciple of expediency and practicality, a shrewd business man as well as an excellent pharmacist, so he wisely dedicated the book to the professors and regents of the Faculty of Medicine of the University of Paris. The somewhat extravagant praise accorded this august body is reminiscent of Le Fevre's dedication to Monsieur Vallot. The dedication is followed by the preface in which, like Glaser, he announces his intention to write in clear language and in which he also, like Glaser, states that the book is divided into three parts: one on minerals, one on plants, one on animals. After the preface is the table of contents, which is followed, not as in Glaser's book by the introduction, but by the agreement of the Faculty of Medicine to the dedication. This is dated July 8, 1673. From its position of prominence in the book one might suppose that the Faculty had had to be persuaded of the value of the book, the first edition of which appeared in 1675. As a matter of fact, this Faculty had approved of Lemery's model on October 25, 1672.

The introduction or general discussion is somewhat shorter than that of Glaser's but the treatment is the same. Both speak of five kinds of substances or principles: three active—spirit or mercury, oil or sulfur, and salt; and of two passive principles—water or liquids, and earth. Section One of both books is on mineral substances and contains 22 chapters; the first in each is on gold, the last, on amber. The arrangement of the chapters is not identical, however: Glaser's chapter on bismuth follows that on mercury; Lemery's chapter on bismuth follows the one on tin. The discussion of arsenic is more logically placed in Lemery's book, where it follows that on antimony, while Glaser places this chapter after that on quicklime. But Glaser recognized the likeness of arsenic to antimony and noted that corrosive liquor of arsenic, the trichloride, has the same properties as butter of antimony except that it is more violent. The chapters in the two books on bismuth will illustrate the similarity of the treatment of subject matter and will show also that Lemery's book is the longer of the two because the author could not resist including here and there a few comments on contemporary theory. This is the account in Glaser's "Traité de la Chymie":

"Bismuth is a kind of Marcasite and is a sulfurous and earthy mineral which is found usually in or near mines of tin. It is hardly ever used except on the exterior and its chief preparations are the magistery and the flowers.

"Zinc is strongly of the nature of bismuth, but contains a sulfur more pure. It can be prepared in the same way and even the preparations have the qualities and virtues of those of bismuth.

MAGISTERY OF BISMUTH

"Powder two ounces of bismuth and put into a flask and pour in six ounces of good spirit of niter, place the flask upon hot sand until the bismuth is entirely dissolved as it will be in about a half hour, pour the hot solution into a large dish in which there is eight or ten pounds of fountain water and you will see the mixture of the solution of bismuth with the water become milky and little by little become clear, and the bismuth leaving the spirits

of niter, which held it in solution, precipitate as a white powder on the bottom of the vessel. The powder being well settled, pour off the water by inclination and replace it with new and repeat the washing until the powder is well freed of the solution, which you should dry in the shade and keep for your use. This is a very good cosmetic mixed in pomades, or in the waters of nymphea or wild tansy and others; it is used also for the itch and for diseases of the skin."

The following is the account of bismuth in the second edition of "Cours de Chymie":

"Bismuth is a sulfurous Marcassite, which is found in mines of tin, many believe that it is an imperfect tin which contains much arsenic; its pores are arranged differently from those of tin, and one can recognize it because the menstruum which dissolves bismuth cannot dissolve entirely tin.

"There is another kind of Marcassite, called zinc, which strongly resembles bismuth, from which one can make the same preparations which we are going to describe.

"The Marcassite is nothing but the excrement of a metal, or an earth filled with metallic parts.

"The pewterers mix bismuth and zinc with tin to make it sound better.

MAGISTERY OF BISMUTH

"Dissolve in a flask one ounce of grossly powdered bismuth in three ounces of spirit of niter: Pour the solution in a well cleaned dish and add five or six pounds of fountain water in which you have previously dissolved one ounce of sea salt, you will see precipitate to the bottom a white powder. Pour off the water by inclination and wash this magistery several times, then dry it in the shade. This is a cosmetic, called Spanish white, which whitens the face. It is used mixed in a pomade or diluted in water of lilies."

These directions are then followed in the "Cours de Chymie" by two pages of the usual "Remarques" which include some theory. In the remarks Lemery notes that there is a great ebullition as soon as the spirit of niter is poured on the mineral, and that the vapors are injurious to the lungs. He also recognizes the difficulty of explaining why water alone precipitates bismuth, lead, and antimony, which have been dissolved in the acid, but does not precipitate gold, silver, or mercury, similarly treated, without the addition of some salt or other body.

The second section of both books on plant substances contains similar material but the arrangement is different. Section Three in both books is short—Lemery's having only three chapters, Glaser's eight.

Glaser, in describing the calcination of lead, noted that one pound of lead was augmented by more than two ounces and remarked that this increase can be observed with tin and other imperfect metals. Lemery also recorded such increases and in later editions of his treatise one finds more and more references to weights of materials used and weight of product obtained. Lemery described the preparation of sel polychreste made according to Glaser's directions but he did not mention Glaser's name. In the remarks Lemery stated that its medicinal properties agreed with those of the same preparation by Monsieur Seignette, who, by the way, in the January after Glaser's departure obtained a patent for the preparation of the famous remedy (*12*).

Any account of Glaser should do more than merely mention his implication in the de Brinvilliers poison case. An excellent bibliography of the references dealing with this affair has been published by Ferguson (*13*) and an examination of these sources proves that there was no evidence of any consequence against Glaser. The story may be told very simply as follows:

Marie Madeline d'Aubray, daughter of a man of some wealth, the Lieutenant General of the Mines of France, married Antoine Gobelin de Brinvilliers in 1651. She was then twenty-one years old and had received a good education. Sometime after 1659 Gaudin de Sainte-Croix became the lover of la Marquise. In order to avoid a public scandal the d'Aubrays obtained a *lettre de cachet* from the king, and Sainte-Croix was sent to the Bastille in March, 1663, where he remained about three months. While there he is said to have learned the art of poisoning from Exili, an Italian who had been in the service of Queen Christina of Sweden. After his release from the Bastille Sainte-Croix seems to have prospered, for he married and lived well. According to some accounts he also set up a laboratory. Early in 1666 Madame de Brinvilliers, anxious to inherit her share of her father's estate to pay her debts, poisoned her father. In June, 1670, she poisoned her older brother, and in September of the same year the younger brother was also poisoned. Autopsies were held in all three cases but since there was no test for arsenic poisoning at this time, nor for some 180 years later, the poisoning, though suspected, was not confirmed. Sainte-Croix died in July, 1672, and in August the contents of his house were inventoried by the police. A casket was found containing a letter written by Sainte-Croix asking that the casket with its contents be delivered to Madame de Brinvilliers. Besides odds and ends of pharmaceutical interest, the casket contained a quantity of corrosive sublimate and two packets, one addressed to Pennautier (which, incidentally, sent him to the Bastille for a time) and one containing letters written by la Marquise to Sainte-Croix, in one of which she mentioned using "la recette de Glaser" as a poison. A servant of Sainte-Croix was arrested early in September, 1672, and Madame de Brinvilliers fled. She was arrested in Liége, March 25, 1676, and brought to Paris for trial. She was beheaded July 17, 1676, at eight in the evening and her body was burned.

During her trial she said that Sainte-Croix knew Glaser and that he had usually obtained the poison from Glaser, though he had sometimes made it himself. Just what the word "recette" meant was never satisfactorily explained. There was nothing incriminatory in the statement that the poison was obtained from Glaser, since white arsenic was sold by apothecaries and grocers in Paris and London during this century and the next for the extermination of rats and mice. As a direct result of this trial, referred to in French literature as "l'Affaire des Poisons," an edict was issued by Louis XIV in July, 1682, which charged those who had the right by their professions or trades to sell or buy poisonous minerals with certain obligations:

"to keep them in a safe place to which they, themselves, have the key; to keep a particular register in which shall be recorded the kind of remedy sold, in what form the mineral was sold, the names of those to whom it was sold, the quantity sold; to record in this register at the end of each year the amount of each poisonous mineral that remained on hand" (*14*).

Such a law was not passed in England until about one hundred years later.

Courtesy of D. D. Berolzheimer

"LE CHIMISTE" BY FRANZ VAN MIERIS, NO. 121 OF THE BEROLZHEIMER ALCHEMICAL AND HISTORICAL REPRODUCTIONS

In the January, 1941, number of *Industrial and Engineering Chemistry* appeared No. 121 of the Berolzheimer Alchemical and Historical Reproductions. It is a copy of an engraving of a painting, "Le Chimiste," by Franz van Mieris. Mr. Berolzheimer states that the original was owned by le Duc d'Orleans and that unlike most paintings of this type and age there is no salamander in the picture. The title page of the second edition of Glaser's treatise places him as an ordinary apothecary to the king and to the duke. Van Mieris died in 1681 so the subject could not have been Guillaume Homberg who became apothecary to the duke about 1702. The writer is hazarding the guess that it was done by order of le Duc d'Orleans and is a painting of the laboratory in the faubourg St. Germain with the old chemist Christopher Glaser looking down into a pot of "Sel Polychreste."

The author wishes to thank the following for their courteous assistance: the Tulane Graduate School for money for photostats; Professor Lionel Durel of the Department of French, Newcomb College; Mrs. Corinne M. Simons of the Lloyd Library in Cincinnati; Mr. W. B. McDaniel, 2nd, of the Library of the College of Physicians in Philadelphia; Miss Eva Armstrong of the Edgar Fahs Smith Memorial Collection in the University of Pennsylvania; Professor George Sarton of Harvard University; and the staff of the Harvard College Library.

LITERATURE CITED

(1) HÄFLIGER, "Das Apothekenwesen Basels," Gesellschaft für Geschichte der Pharmazie, Berlin, **1937–38,** p. 106.
(2) DE MILT, "Early chemistry at Le Jardin du Roi," J. CHEM. EDUC., **18,** 503–10 (Nov., 1941).
(3) GOBET, "Les anciens minéralogistes," Ruault, Paris, **1779,** Vol. 1, p. xxxiv.
(4) FERGUSON, "*Bibliotheca chemica,*" Maclehose and Sons, Glasgow, **1906,** Vol. 1, p. 321.
(5) LEMERY, "A course of chymistry," translated from the 5th French edition by WALTER HARRIS, M.D., 2nd ed., printed by R. N. for Walter Kettilby, London, **1686,** p. 294. There is a copy in the Harvard Library.
(6) BOERHAAVE, "A new method of chemistry," translated by PETER SHAW, 3rd ed., Longmans, London, **1753,** p. 47.
(7) HOEFER, "Histoire de la chimie," Didot Frères, Paris, **1869,** Vol. 11, p. 282.
(8) BOUVET, "Histoire de la pharmacie en France," Editions Occitania, Paris, **1937,** p. 88.
(9) LIPPMANN, "Die Geschichte des Wismuts," Springer, Berlin, **1930,** p. 30.
(10) DUMAS, "Leçons sur la philosophie chimique," Gauthier-Villars, Paris, **1878,** pp. 69–70.
(11) LEMERY, "Cours de chymie," Chez l'Autheur, Paris, **1681.** There is a copy in the Harvard Library.
(12) BOUVET, *op. cit.*, p. 173.
(13) FERGUSON, *op. cit.*, p. 321.
(14) BOUVET, *op. cit.*, p. 318.

GOVERNMENT NEEDS MORE SCIENTISTS

IN AN effort to meet the increasing needs of the defense program for scientifically trained men and women, the Federal Civil Service Commission has reannounced, with modified requirements, three of its examinations for scientists. The reannounced examinations are those for Analytical and Research Chemist, Explosives Chemist, and Chemical Engineer positions, with salaries in each field ranging from $2600 to $5600 a year. For all, appropriate college study and experience are required.

For analytical and research chemists (Announcement 185) any specialized branch of chemistry is included.

In chemical engineering there is a shortage of qualified people in plant layout, equipment design, market analysis, chemical economics, heavy chemicals, plastics, rubber, agricultural by-products and strategic minerals. Applicants may now substitute college teaching in chemical engineering or chemistry for part of the prescribed experience.

Over 100 explosives chemists are needed. In this examination the term "explosives chemistry" is interpreted to mean "research, developmental or production work on explosives, or materials which require for their preparation and handling, methods, technics, and precautionary measures similar to those used for explosives."

The age limit has been raised to 60 years, for regular probational appointment. Provision is also made for the waiver of age and physical requirements for temporary positions. The announcements and application forms may be obtained at any first- or second-class post office or from the Civil Service Commission in Washington, D. C. Qualified persons are urged to apply at once.

The Measurement of Surface Tension: A Laboratory Experiment[1]

THOMAS H. HAZLEHURST *Lehigh University, Bethlehem, Pennsylvania*

LABORATORY exercises on measuring surface tension are for the most part confined to (1) the capillary rise method, (2) the drop weight method, and (3) the ring method. The simple, convenient, and accurate method of maximum bubble pressure, developed by Sugden (*3*, *4*) has been passed over regrettably. In an effort to make teachers aware of its eminent feasibility and to popularize the use of this neglected technic as a laboratory exercise, the present paper describes the apparatus, summarizes the theory behind its use, and cites typical results.

The apparatus consists essentially of two capillary tubes, an open tube manometer, and some method of providing gentle suction. The simplest setup will be described here. The capillaries are drawn from ordinary glass tubing and should have diameters at the outlets of 0.5 to 2 mm. and 0.05 to 0.2 mm., respectively. The exact diameter of neither is important, although it is necessary to know the internal diameter of the larger capillary to within about 0.1 mm. This can be found with a magnifier and a scale, although of course a microscope with micrometer eyepiece will give a far more accurate result. The manometer is simply constructed of small-bore glass tubing and is attached to a meter stick. The manometer liquid advocated by Sugden is absolute alcohol colored by a trace of dye. The gentle suction is readily applied by the use of mercury (or any other liquid) in a dropping funnel, the tip of which is drawn to capillary dimensions, connected to the apparatus as shown in Figure 1. The sample to be investigated is placed in a small container so that the capillaries dip into it as shown.

The only essential precautions in setting up this simple equipment are that the capillaries must both extend to exactly the same depth in the sample in any one experiment and that they must be vertical. The reason for these precautions will appear later. Of course all connections must be airtight. They can readily be tested by shutting the tube through which the air enters, running the mercury until a fairly high suction is shown on the manometer, and allowing the apparatus to stand. If the manometer liquid preserves its level for several minutes, the joints are satisfactory.

The exact formula used to calculate surface tension from measurements made with such apparatus is

$$\sigma = P/2\ (1/X' - 1/X'') \qquad (1)$$

Here σ is the surface tension of the sample, P is the difference in pressure (dynes per square centimeter) required to suck air through the two capillaries, and the X's are quantities closely related to the radii of the outlets of the capillaries. An approximate formula, developed by Sugden and entirely adequate for student work and, indeed, for most research work is

$$\sigma = AP\ (1 + 0.69r''gD/P) \qquad (2)$$

Here A is an empirical constant characteristic of the apparatus, r'' is the radius (in centimeters) of the *larger* capillary, D is the density (grams per cubic centimeter) of the liquid sample, g is the acceleration of gravity, and σ and P have the same significance as in (1). Since the second term in parenthesis is only a correction factor anyhow, the values of r'' and D need not be known very accurately. The whole expression in parenthesis seldom departs from unity by more than 4 per cent.

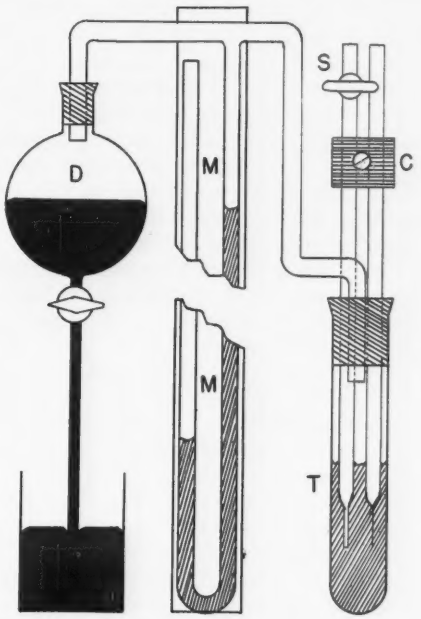


FIGURE 1.—APPARATUS FOR MEASURING SURFACE TENSION BY SUGDEN'S MODIFICATION OF THE MAXIMUM BUBBLE PRESSURE METHOD

D = dropping funnel with mercury to provide gentle suction. M = alcohol manometer attached to meter stick. T = tube containing sample, fitted with 3-holed stopper bearing fine and coarse capillaries and outlet tube. C = clamp holding two capillaries rigidly together. S = stopcock to permit closing off larger capillary

The quantities which must be known or measured

[1] Presented before the Division of Chemical Education at the 102nd meeting of the A. C. S., Atlantic City, New Jersey, September 9, 1941.

during the experiment are (1) the approximate radius of the larger capillary, (2) the temperature and approximate density of the liquid sample, (3) the maximum pressures developed when air is bubbling slowly (one bubble per second or less) through each of the two capillaries, and (4) the density and temperature of the manometer liquid. The radius of the larger capillary is most simply obtained during its manufacture by drawing out a larger tube, making a fine scratch at the desired breaking point, and breaking cleanly. One end is used in the apparatus and the other is examined with a hand lens or microscope and its approximate internal diameter measured. Since the same capillaries, small and large, may be used in an indefinite number of experiments, a single determination of the capillary radius is sufficient until some accident breaks the tube. The sample can be considered to be at room temperature in most cases but can readily be maintained at a uniform temperature by surrounding the container with a water bath. The whole measurement takes less than ten minutes and the temperature will not vary appreciably over that interval. The density of the sample may be determined in a separate experiment to within about 10 per cent by any crude method or may be obtained by consulting a handbook in most cases. Commonly the manometer liquid may be assumed to be at room temperature although it, too, may be jacketed if desired, and the density of the absolute alcohol employed is obtainable in handbooks.

The apparatus is designed so that bubbles form and break away at the outlets of the tubes when mercury flows in the funnel. If both tubes are open, bubbles will form only at the larger one because a much higher pressure is required to force air through the smaller capillary. As the bubble forms, the manometer indicates increasing suction and then, just as the bubble is about to break away, the suction reaches its maximum and falls abruptly. With a little practice it is easy to locate the highest level reached in the closed arm of the manometer and the lowest level reached in the other arm. If air is now prevented from entering the larger capillary by a pinch clamp or stopcock, bubbles will form at the smaller capillary. The escaping bubbles are so small that, when one of them escapes, the fall of the manometer liquid is almost imperceptible to the unaided eye and it is even simpler to locate the highest and lowest levels reached by the manometer liquid.

Let H' and H'' be the maximum pressures in centimeters of manometer liquid, developed in producing bubbles at the mouths of the smaller and larger capillaries, respectively, and let $H = H' - H''$. Then the pressure P (dynes per square centimeter) of formula (2) is given by

$$P = Hg(D' - d')$$

where g is the acceleration of gravity, D' is the density of the manometer fluid at the temperature of the experiment, and d' is the density of the gas above the alcohol. Usually d' is quite negligible in comparison to D' and it is adequate to use the formula

$$P = HgD'$$

The reason why the capillaries must dip to equal depths beneath the surface of the sample is now obvious. If one dipped farther than the other, the extra hydrostatic head required to suck air through it would appear as an error in P. The simplest way to make sure that the tubes do dip equally is to allow them to approach very gradually a plane surface of mercury. It is very easy to tell whether they touch simultaneously and they should be adjusted so that they do. Once the adjustment has been made it should be carefully maintained by a clamp of some sort.

The empirical constant A of formula (2) is obtained by using as a sample a liquid of known surface tension, preferably pure benzene. The surface tensions of water and of benzene have been more thoroughly investigated and are known more exactly than any others. Benzene is a better reference than water since traces of impurities which would markedly lower the high surface tension of water have little effect upon the already low tension of the benzene. Sugden has found that the usual impurities in benzene (thiophene and moisture) have an insignificant effect upon the surface tension, so that only a simple process of purification is necessary even for very accurate work. The benzene is frozen, the most fusible third being rejected. The remainder is distilled through a column of glass beads and the fraction boiling at 80° to 80.5°C. is used. For student work, C.P. benzene is sufficiently pure.

There are two advantages to this method of measuring surface tension apart from its rapidity, convenience, and economy: (1) A fresh surface is formed with each new bubble, so that there is less chance of errors through contamination of a surface upon exposure to air for a short time. (2) Only a minimal quantity of liquid need be used, since it is unnecessary to have a *plane reference surface* such as must be present when the capillary rise method or the ring method is employed. Because of the excessive rapidity with which liquid metallic surfaces become contaminated upon exposure to air, the maximum bubble pressure method is the only one which has given any reliable measures of their tensions. When an inert atmosphere is to be used, this method is eminently appropriate since the sample is already enclosed and it is easy to substitute a source of, say, nitrogen, for the air usually used.

As evidence of what can be done with a minimum of precautions, measurements made with a pair of capillaries, 1.5 mm. and about 0.06 mm. internal diameter, respectively, upon ordinary benzene, commercial absolute alcohol, and laboratory distilled water are given in Table 1. The necessary calculations are noted below. The experiments were made without the use of a temperature control of any kind. Note the reproducibility of the results even though the tenths of millimeters had to be estimated.

In order to be able to reduce manometer differences, Δ, to pressures in dynes/ cm.^{2}, it is convenient to have a table showing the product of g, the acceleration of

TABLE 1

Sample	Room Temperature, °C.	H Cm.	$P \times 10^{-3}$ Dynes/Cm.²	σ Dynes/Cm.²	Manometer Readings Cm. of Absolute Alcohol: Closed Arm	Open Arm	Difference, Δ	Capillary
Benzene (density = 0.88)	22.3	11.31	8.734	(28.58) (standard)	81.20	67.57	13.63	Small
					75.52	73.20	2.32	Large
					81.20	67.57	13.63	Small
					75.51	73.19	2.32	Large
Absolute alcohol (density = 0.78)	24.8	8.65	6.662	21.82	75.09	72.51	2.58	Large
					79.40	68.19	11.21	Small
					75.07	72.51	2.56	Large
					79.42	68.19	11.23	Small
Distilled water (density = 1.00)	25.4	28.61	22.00	71.40	91.49	58.26	33.23	Small
					77.01	72.39	4.62	Large
					91.49	58.26	33.23	Small
					77.00	72.37	4.63	Large
					77.01	72.40	4.61	Large

gravity, and D', the density of the manometer liquid, for a range of temperatures. Table 2 gives such values for absolute alcohol.

TABLE 2

VALUES OF gD', WHERE g = 980.6 AND D' = DENSITY OF ABSOLUTE ETHANOL

$t°$	18	19	20	21	22	23	24	25	26	27	28
gD'	775.7	775.0	774.2	773.3	772.5	771.6	770.8	770.0	769.2	768.3	767.5

To obtain H and P as tabulated in Table 1, say for alcohol, proceed as follows:

H' = 11.22 cm. (average of 11.23 and 11.21)
H'' = 2.57 cm.
$H = H' - H''$ = 8.65 cm. of absolute alcohol at 24.8°C.

Hence,

$$P = HgD' = 8.65 \times 770.2 = 6.662 \times 10^3 \text{ dynes/cm.}^2$$

To find the value of the constant A in (2) use the recorded value of the surface tension of benzene at 22.3°C., namely, 28.58 dynes/cm. Then

$$28.58 = A \times 8.734 \times 10^3 (1 + 0.69 \times 0.15 \times 0.88 \times 981/8.73 \times 10^3)$$
$$= A \times 8.734 \times 10^3 \times 1.009$$

Hence

$$A = 3.237 \times 10^{-3}$$

Note that the omission of the term $0.69r''gD/P$ would have made a difference of less than one per cent in the result.

Using this value of A, we may now calculate the values of the surface tension of alcohol and of water. For example, for alcohol,

$$\sigma = 3.237 \times 10^{-3} \times 6.662 \times 10^3 (1 + 0.69 \times 0.15 \times 981 \times 0.78/6.7 \times 10^3)$$
$$= 3.237 \times 6.662 \times 1.012 = 21.82 \text{ dynes/cm.}$$

This time the "correction factor" is a little over one per cent. The value of the surface tension of absolute alcohol listed in International Critical Tables is 21.86 dynes/cm. at 24.8°C. The agreement is all that could be desired.

A similar calculation for the surface tension of the laboratory distilled water yields 71.40 dynes/cm. as compared with a listed value of 71.90 dynes/cm. The agreement here is still better than one per cent but leaves something to be desired, probably because of contamination due to the designedly crude technic. The water was taken from the laboratory distilled water tap and not redistilled or treated in any way. It is very easy for slight traces of surface tension depressants to manifest their presence in a liquid of high surface tension. Traces of contaminants in alcohol, benzene, or other liquid of already low surface tension would be far less noticeable.

For a thorough treatment of the theory involved in measuring surface tension by the bubble pressure method, reference should be made to the monograph by Bashford and Adams (*2*), the papers by Sugden (*3*, *4*), and the treatise of Adam (*1*). The following merely sketches the ideas involved.

In Figure 2 (a) the outline of a *spherical* bubble during successive stages of its production at the mouth of a capillary under a liquid is shown, together with the successive positions of the center of curvature, C, and the successive lengths of the radius of curvature, r. It is clear that the radius of curvature starts at infinity, reaches a minimum value (in this case the radius of the tube itself), and then increases once more. There is a theorem of surface physics (*5*) that the pressure in a spherical bubble is given by the formula

$$p = 2\sigma/r$$

where σ is the surface tension of the liquid and r is the radius of the bubble. Consequently, when the radius

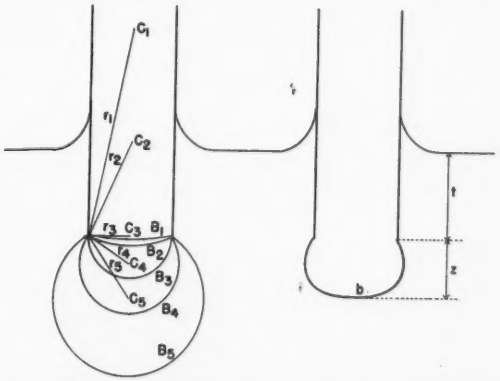


FIGURE 2.—AIR BUBBLES FORMING AT THE MOUTH OF A CAPILLARY BELOW A LIQUID

(a) Successive shapes (B_1 to B_5), centers (C_1 to C_5), and radii of curvature (r_1 to r_5) of a hypothetical *spherical* bubble; (b) actual shape of bubble just before breaking away (b = radius of curvature at "apex" of bubble)

is a *minimum*, the pressure is a *maximum*, and a measurement of the maximum pressure, together with a knowledge of the radius of the tube (which is the same as the minimum radius of the bubble *when the bubble is spherical*), will permit a calculation of the surface tension. However, unless the tube is extremely small, the shape of the bubble departs noticeably from the spherical. Figure 2 (b) shows the actual shape of the bubble when about to break away from the tube. Obviously the radius of curvature varies for different portions of the bubble and will not be the same as the radius of the tube except by some rare accident. A strict derivation proves that the correct formula connecting the maximum pressure and the surface tension is

$$p = 2\sigma/b + zg(D - d)$$

Here p is the pressure *not counting the pressure due to the layer of liquid t cm. deep between the free plane surface and the outlet of the tube*, b is the radius of curvature at the apex of the bubble, g is the acceleration of gravity, D is the density of the liquid phase, d is the density of the gaseous phase (usually negligible in comparison with D), and z is the "height" of the bubble, *i. e.*, the distance of the apex below the mouth of the tube. This pressure p would be exerted by a column of liquid sample h cm. in height if

$$p = hg(D - d), \text{ or } h = p/g(D - d) = 2/bg(D - d) + z$$

If we introduce the so-called capillary constant, a^2, defined by

$$a^2 = 2/g(D - d)$$

the formula for h becomes

$$h = a^2/b + z$$

The capillary constant, a^2, appears frequently in the theory of surface tension. The simple formula relating surface tension to the radius of a capillary and the height, l, to which the liquid will rise in it is

$$\sigma = lgDr/2, \quad lr = 2\sigma/gD$$

Hence, for a given liquid at a given temperature, lr is constant. The exact formula substitutes for r the quantity b (radius of curvature at the bottom of the meniscus) and for D the quantity $D - d$, so that it is

$$lb = 2\sigma/g(D - d)$$

which is constant. This is the capillary constant and it has the dimensions of length times length. The standard symbol for it is a^2 and it is usually expressed in square mm. It is used in this derivation solely as an abbreviation for the quantity

$$2\sigma/g(D - d)$$

Finally, let $X = a^2/h$. Then the actual maximum pressure observed, measured in cm. of the liquid under investigation, will be

$$q = h + t = a^2/X + t$$

Obviously, in order to use this formula to find σ, we must know (1) the value of t and (2) the relationship between X and r, for r and q may be measured directly and σ may be obtained from a^2 by the formula

$$\sigma = a^2g(D - d)/2$$

In order to avoid the measurement of t, which would be troublesome since a large quantity of liquid would be needed to insure a truly plane reference surface, Sugden proposed the use of *two* capillaries. Let quantities appropriate to the two capillaries be distinguished by single and double primes and let

$$Q = q' - q''$$

be the difference in maximum pressures for the two capillaries, *measured in cm. of the liquid* under investigation. Then

$$q' = a^2/X' = t; \quad q'' = a^2/X'' + t$$
$$Q = a^2(1/X' + 1/X'')$$

and the quantity t has disappeared. *This will happen only if t is the same for both capillaries, that is, if they project to exactly equal depths beneath the surface.*

The pressure corresponding to Q cm. of the liquid sample will be

$$P = Qg(D - d) = Hg(D' - d')$$

where H is the height of a column of manometer liquid just balancing Q cm. of sample liquid, and D' and d' are the densities of the liquid and gas phases in the manometer. Hence,

$$\sigma = a^2g(D - d)/2 = Qg(D - d)/2\,(1/X' + 1/X'')$$
$$= P/2\,(1/X' + 1/X'') = Hg(D' - d')/2\,(1/X' + 1/X'')$$

This formula is exact. Its use depends upon our ability to correlate X' with r' and X'' with r''. The correlation can be performed only by a series of numerical approximations (involving the invaluable tables of Bashford and Adams and a table derived by Sugden) and the values of both r' and r'' must be measured as accurately as possible. For the application of this formula reference may be made to Sugden's papers or Adam's treatise.

The approximate formula (2), which is amply accurate for student experimentation and most research work, is arrived at as follows. If r' is very small (hundredths of a millimeter), X' is nearly equal to r' and in any case will vary very little from liquid to liquid. The relationship of X'' to r'' depends upon the value of r'' and the surface tension of the liquid to be measured, that is, indirectly upon P itself. Hence we may infer that a suitable form of empirical equation is

$$\sigma = Px \text{ (a constant)} \times \text{(a correction factor)}$$

where the correction factor will involve only r'' and the surface tension of the sample and will be larger the smaller the surface tension. Sugden found that his very accurate experiments could be reproduced satisfactorily by means of the equation

$$\sigma = AP(1 + 0.69r''gD/P) \qquad (2)$$

The sources of error in measuring P are (1) error in reading the manometer scale, which can easily be kept below 0.2 mm., (2) error in the density of the manometer liquid, which can be kept to less than 0.1 per cent, and (3) error caused by the manometer scale being out of the vertical, which, with reasonable care,

is negligible. Since it is practicable to have a net manometer reading of as much as 8 cm. even for a liquid of low surface tension such as alcohol, the overall error in P should be no more than 0.25 per cent even in student manipulation.

The only other significant source of error lies in forming and setting up the capillaries. The outlets should be truly circular, but Sugden has shown that a moderate degree of ellipticity has very little effect and that this source of error may usually be ignored. The error involved in having one tube project more deeply than another may be kept to less than 0.1 mm. and so is of the same order of magnitude as the error in P. A departure of the capillaries from a truly vertical position introduces little error unless the tilt is such that one tube dips more deeply than the other. In that case it may become serious, the difference in depth at the outlets being given by

$$\Delta = d \sin \alpha$$

where d is the distance between the axes of the two tubes and α is the angular departure from the vertical due to rotation about a horizontal axis perpendicular to the plane of the tubes. This type of rotation introduces maximum error. If d is one cm. and α is as much as 5°, $\Delta = 0.9$ mm. If the tilt in this direction is kept below 1°, $\Delta = 0.17$ mm. or less. This error is further reduced if the tubes, regardless of a slight slant, are adjusted to dip to the same depth.

On the whole, there is no reason why even a routine student setup should not give values accurate to better than one per cent. Once the apparatus has been set up, a whole series of measurements can be made in a very short time, since the manometer readings required can be made in less than five minutes and the process of cleaning the tubes after a run and introducing a new sample will take only about another five minutes. The same pair of capillaries can be used indefinitely in the absence of breakage unless the finer one becomes clogged by dust. This may be avoided by filtering the incoming air through a bit of cotton, and in any event a new fine capillary can be readily standardized by a single run with benzene.

The construction and use of the equipment is well within the powers of high-school students. The cost is extremely low as compared to that of the ring or drop weight methods. In conclusion, it is urged that there be more widespread use of this simple, convenient, and rapid technic of surface tension measurement.

LITERATURE CITED

(1) ADAM, "The physics and chemistry of surfaces," The Clarendon Press, Oxford, England, **1930,** 332 pp.
(2) BASHFORD AND ADAMS, "Capillary action," Cambridge University Press, Cambridge, England, **1883.**
(3) SUGDEN, *J. Chem. Soc.*, **121,** 858 (1922).
(4) SUGDEN, *ibid.*, **125,** 27 (1924).
(5) ADAM, *op. cit.*, p. 12 ff.

MURAL IN SCIENCE LIBRARY, BRYN MAWR COLLEGE

(Frontispiece)

IN A 7-foot by 10-foot recessed panel, Miss Mildred Burrage has painted the mural called the "History of Chemistry" in the Library of the Science Building of Bryn Mawr College.

The panel, an upright, is divided horizontally into three sections. In the first are shown the elements, in the second section, alchemy, and in the third panel are shown the series of discoveries which brought about such changes in the world of science in the nineteenth century. Diagrams and equations are worked into a decorative pattern, and the result is something new in modern art—for it is art dealing with pure abstractions, but still abstractions about whose meaning there is no doubt to the chemistry students who use the Library.

The first panel shows the four elements known to the ancients—Earth, Water, Air, Fire. It shows a half circle of Earth, surrounded by a half circle of Water with fishes, then a half circle of sky and clouds for Air with winds blowing the clouds, then another half circle of Flames. Above the band of flames is the sun and on each side are the moon and the planets; above them appear the symbols of the metals they represent. These symbols were found in a series of planet pictures—woodcuts made by Hans Sebalt Behans about 1531, probably at Nuremberg. From the sun, rays spread out to the upper corners of the panel where they meet the spectrum of the sun, and form a background for the alchemy panel and the modern panel.

The second panel is concerned with alchemy, the chemistry of the middle ages. In the center is an alchemical furnace and figures of two apprentices which are taken from a painting in a fifteenth century manuscript copy of Norton's *Ordinall*. Above them are the four symbols of the Great Work, the Philosophers' Stone, the Philosophers' Egg, the Vase of Hermes, and one of Basil Valentine's symbolic emblems. The scroll on the left with the names of the Arabs, and the scroll on the right with the names of Albertus Magnus, Roger Bacon, and Lully, commemorate the early alchemists.

In the third panel the scrolls continue on to commemorate Iatro-chemistry and the Phlogiston Theory, movements which came to nothing. Names of chemists who in modern times have influenced the development of chemistry are included in this panel. The list starts with Robert Boyle and ends with Curie and the alpha, beta, and gamma rays of radium. The panel ends with a quotation from Aristotle, which reads:

"For that out of which all existent things are formed and into which at the last they are consumed, *this* they say is an *element*."

The companion piece to the chemistry mural, at the opposite end of the Library, is a geological time table that shows the rise of life. Both murals have been painted with a gesso ground—a mixture used by early Italian painters as a ground on wooden panels. It is very durable and colors applied to it do not change, but remain beautifully brilliant. The actual painting is done with watercolor, and the finished picture protected with a waterproof finish.

The artist, Mildred Burrage, is a native of Maine. Her specialty has been maps and decorative paintings, although she has also painted many portraits. The end papers, in the maps in Kenneth Roberts' series of historical novels, are Miss Burrage's work.

Writing of her experience while painting the mural Miss Burrage has said, "An artist usually works alone, but I had help from members of the Bryn Mawr faculty, and it was such a stimulating and delightful experience that I wish more painters could have it. The Renaissance painters must have had just such learned help in Florence and Rome when painting decorations with classical allusions for the Medici or Borgias."

Polarizing Accessories for Microscopes

C. D. WEST *Polaroid Corporation, Cambridge, Massachusetts*

A POLARIZING microscope has much wider functions than the more widely used and hence more familiar medical microscope. While the latter gives only a magnified image of an object, in the former simple magnification is secondary to the determination of the crystal-optical character of the object magnified. This is a considerably larger undertaking than the mere detection of optical anisotropy—dichroism or birefringence—in microscopic objects. To detect dichroism under the microscope one requires only a single polarizer somewhere in the light path, most conveniently perhaps over the eyepiece (cap analyzer); and birefringence is observed by inserting a second polarizer in the light path, crossed with the first and on the other side of the object, as for example below the stage. Such elementary polarizing accessories need no special mention here, as they have already been described in the literature of several manufacturers. But it should be recognized at the start that the detection of optical anisotropy in an object, whether microscopic or macroscopic, is only the first and the easiest step in a series of operations leading to the determination of its crystal-optical constants. It is with the means for carrying out these more extended operations that we are here concerned.

There is already published an extensive literature describing the construction of the polarizing microscope and its use in such fields as mineralogy, chemistry, and biology, and in the examination of such technical products as textile and paper fibers, pigments, drugs, etc.; hence a review is hardly needed here. But in spite of its potentially wide range of applications, the polarizing microscope can hardly be said to be very widely used (at least outside of mineralogy) at present. This condition probably results from two circumstances, the relatively high cost of the instrument and its accessories on the one hand, and the difficulty of the technic of using it on the other.

The first difficulty would be somewhat lessened if there were simple and inexpensive ways of adapting medical microscopes for use as polarizing instruments. Such adaptations were plainly not practical when the only suitable polarizers available were made of calcite; this is shown by the lack of literature on this subject. Today, however, such adaptations are eminently practical and within the reach of most laboratory workers through the means of efficient dichroic film polarizers. The purpose of this paper is to describe some accessories which facilitate the conversion of medical microscopes into polarizing instruments.

In designing such accessories the main problem is to choose the most advantageous locations for the polarizers. In making this choice it is to be recognized that film polarizers are not subject to the limitations inherent in calcite polarizers, namely small aperture, great thickness, and astigmatism. This means that most of the experience accumulated with calcite polarizers in polarizing instruments may be well disregarded or forgotten, and leaves the way open to entirely new designs. For the present, however, we are less concerned with designing new microscopes than we are with adapting old microscopes for new uses.

The second difficulty, that of technic, remains unchanged, for a good understanding of the concepts of crystallography and of polarized light optics will always be required background for the most effective use of the polarizing microscope. It may not be out of place, however, to point out that a simple and logical approach to the optics required lies through practice in the examination of transparent macroscopic objects in a simple vertical polariscope, since from such operations there is a direct transition to the examination of transparent microscopic objects in a polarizing microscope.

We are now ready to describe in order, starting at the top, the various parts and modifications of an adaptation using a fixed analyzer and a removable polarizer, and applicable to the widest possible variety of microscopes.

1. Analyzer and Eyepiece

A cap analyzer fitting over the eyepiece is less desirable, first, because external dimensions vary among eyepieces made by different manufacturers, second, because even a thin analyzer here generally cuts down the field of view. There are two better positions than this for the fixed analyzer, which in any case should be a $^3/_4$-inch disc, laminated between glass, and of good quality.

A. The preferred position for the disc analyzer is probably at the bottom of the eyepiece tube, whether this is of the fixed length or of the variable length (draw tube) type. Both types of eyepiece tube can generally be rotated. For this arrangement it is easiest to start with a Huyghenian eyepiece of, say, 10× magnification, which has been provided by the maker with cross lines in the focal plane of the eye lens, and with a pin at the end of the diameter marked by one of the cross lines. Such eyepieces are listed as standard equipment for petrographic microscopes. Alternatively it is not difficult to equip an ordinary Huyghenian eyepiece with these parts; a glass disc with engraved cross lines (reticle) to fit inside the eyepiece is easily obtainable from optical dealers.

The disc analyzer is first permanently fixed at the bottom of the eyepiece tube with vibration direction from left to right, the eyepiece is inserted and rotated until a cross line is exactly parallel to the analyzer vibration direction, a mark is made at the top of the eyepiece tube showing the position of the eyepiece pin,

and a notch is then filed out at this point to fit the pin. In this way, whenever the eyepiece is in use the pin is engaged by the notch and the analyzer vibration direction is shown by the cross line.

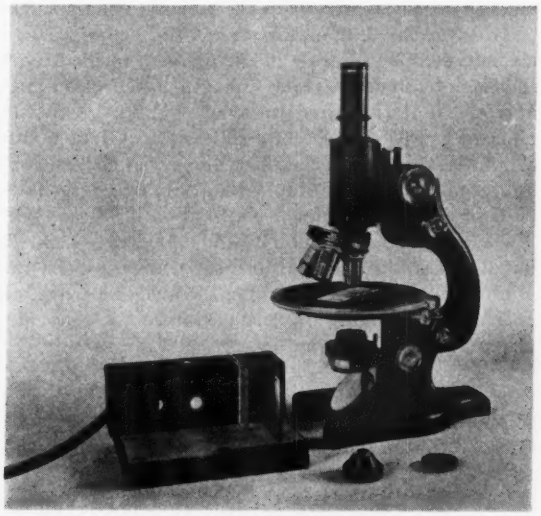


FIGURE 1

Medical microscope with rotating stage, petrographic eyepiece, analyzer in draw tube, top lens of condenser removed, polarizer in "out" position, set for orthoscopic view with 16-mm. objective

B. An alternative position for the analyzer, perhaps easier to provide, is in the eyepiece itself. Here one might start as before with a petrographic eyepiece, and insert the disc analyzer above the field lens with its vibration direction parallel to one of the cross lines. It appears simpler, however, merely to cement a reticle to the disc analyzer, again so that the vibration direction is permanently marked by one of the cross lines; this assembly then needs only to be dropped into any standard eyepiece, so as to bring the cross lines into the focal plane of the eye lens, in order to achieve a satisfactory analyzer eyepiece.

2. Pinhole Aperture

Interference figures will generally be viewed by the Lasaulx method—that is, simply by removing the eyepiece. To sharpen the figures it will frequently be desirable to replace the eyepiece with a pinhole aperture. For arrangement (*A*) of the preceding section no special directions are necessary, while for arrangement (*B*) it is obvious that the pinhole aperture will have to be provided with its own analyzer in order to view interference figures.

3. Objectives

A selection of 16-mm. NA 0.25, 4-mm. NA 0.66, and 1.8-mm. NA 1.25 objectives will be found useful; most of the work is done with the first two of these, which are dry objectives. The front lens of the 16-mm. lens is generally removable, leaving an objective of lower power which will be needed occasionally.

The objectives, as well as other lenses situated between the polarizers, should be examined in a polariscope for freedom from strain birefringence.

4. Stage

The choice of stage depends on whether one intends to do general work or special work with the polarizing microscope, as will be treated in a later section.

A. For the most general work it is necessary to have a graduated rotating stage, and means for centering each objective on the rotation axis of the stage. Since standard medical microscopes have revolving nosepieces without provision for individually centering the objectives, the rotating stage should be centerable. Such a stage can generally be purchased from the maker of the microscope, and it should be fitted to the instrument by him.

It should be noted that a graduated rotating stage has several uses outside the field of purely microscopic observations; for example, it is easy to adapt such a stage for polarimetric measurements.

B. For special work with the polarizing microscope the ordinary fixed stage will suffice, as will be treated in a later section.

5. Condenser

The top lens of the substage condenser should be easily removable and replaceable; it is ordinarily removed for orthoscopic viewing, and replaced for conoscopic viewing of objects in polarized light.

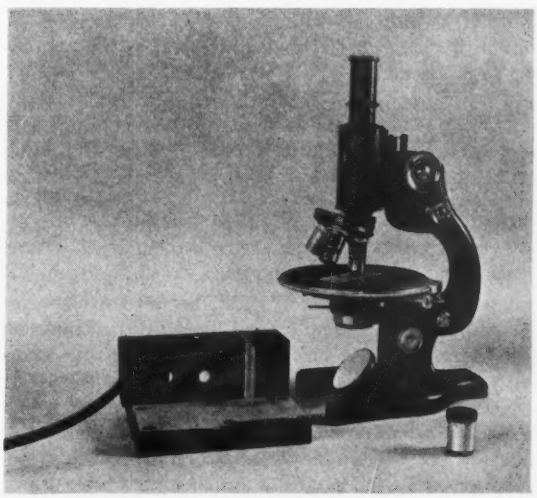


FIGURE 2

Same as Figure 1, with eyepiece replaced by pinhole aperture, polarizer in "in" position, set for conoscopic view with 4-mm. objective

This operation may prove to be too tedious or cumbersome with some makes of instruments. In this case, the top lens of the condenser is removed per-

manently, and its place is taken by a small strain-free hemispherical lens cemented to the underside of a glass slide, which fits a brass frame fixed to the top of the

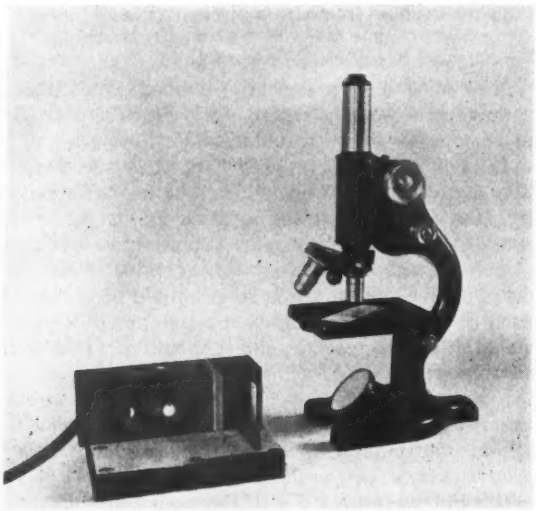


FIGURE 3
Students' microscope with fixed stage, analyzer in eyepiece

stage. A lens about 6 mm. in diameter will suffice, and it should be at a level to fill wholly the aperture of the high power objective with which it is to be used—for example, the NA 0.66 dry objective mentioned above.

An iris diaphragm in the substage assembly is practically necessary, because in determining refractive indexes of solids by the immersion method one is continuously changing the angle of the cone of light traversing the specimen.

The plane mirror regularly supplied with medical microscopes is preferably used, since it is not possible to get a uniformly polarized reflected beam from a uniformly polarized incident beam by means of a concave mirror at 45° incidence.

6. Polarizer

For the removable polarizer a position below the condenser is less desirable, first, because space here is generally cramped, and second, because the dimensions and construction at this point vary among microscopes with the manufacturer.

To get around these difficulties the polarizer is made a part of an illuminator entirely independent of the microscope. A simple way to construct this is to start with a 6-inch length of 2-inch square brass tubing. This is provided with a 15-watt, 110-volt lamp in a standard receptacle at one end, and with slots at the other end to receive the polarizer and compensator plates, color filters and diffusing screen, apertures, etc. The brass tube is supported on a base such as a $^1/_2$-inch board. A more intense and whiter light is obtained with a 32 C 6-volt headlight lamp in the same illuminator.

An aperture plate with circular apertures of varying diameters is also useful with the illuminator.

The polarizing plate is in the shape of a 2- by 3-inch rectangular glass lamination, with vibration direction parallel to the shorter edge; this direction should be marked on all polarizers by the maker. The polarized beam from the illuminator strikes the plane mirror of the microscope vibrating in the plane of incidence, and thus is not subject to phase changes on reflection in the mirror. If it is desired to reflect light from the illuminator up the microscope tube polarized in oblique azimuths, then a front surface plane metallic mirror is indicated in combination with a suitable retardation plate properly positioned in the light path.

We may digress to point out that when this illuminator is stood on end, it furnishes the bottom element of a useful vertical polariscope, the analyzer being supported, for example, by a ring stand at a convenient height above the illuminator.

7. Compensator Plates

These are made of birefringent film, rectangular in shape with the slow ray parallel to the longer edge; this direction should be marked by the maker. They are usually introduced in the light path below the stage supported only by hand. Such plates include a sensitive tint or full-wave plate, a quarter-wave plate, and a

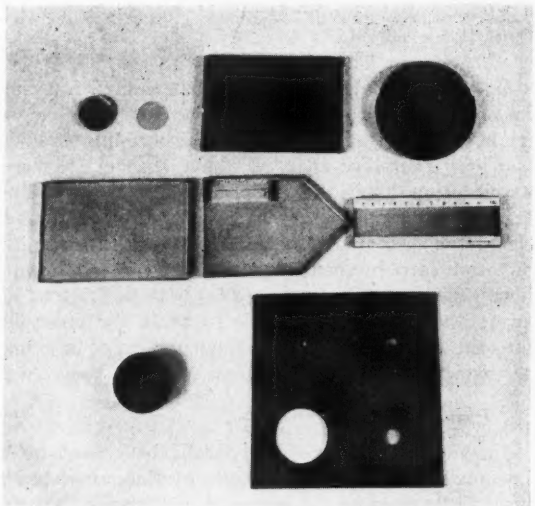


FIGURE 4
Top row: Analyzer, reticle, and two forms of polarizer for the illuminator
Middle row: Two forms of retardation plate, step plate
Bottom row: Pinhole aperture, apertures for illuminator

step plate of 12 steps rising by quarter-wave intervals to three-wave lengths. The device of using a disc polarizer in combination with the quarter-wave plate in the illuminator to give a Senarmont compensator was previously described by the writer.[1] This disc

[1] WEST, *Am. Mineral.*, **23**, 531 (1938).

polarizer, about $2^3/_8$ inches in diameter, can also be used as analyzer for the vertical polariscope just mentioned.

OPERATION

With the rotating stage, the polarizing microscope equipped as described in the foregoing paragraphs is suitable for the general problem of determining the lengths and directions of the ellipsoid axes α, β, and γ of an unknown crystalline species. As described in the reference works listed in the bibliography, the directions of the ellipsoid axes are customarily found by means of interference figures; and their lengths, corresponding to principal refractive indexes, are determined by the immersion method, using polarized light.

If the polarizing microscope lacks a rotating stage (or what is equivalent, means for rotating the crossed polarizers simultaneously), but has only a fixed stage, then in general it is not profitable to undertake the complete determination of the triaxial ellipsoid of an unknown crystalline species. The reason for this is, that without a rotating stage it is not practical to identify the ellipsoid axes by means of interference figures. Frequently, however, the grains or particles of a given species will be found to present quite consistently one and the same section of the triaxial ellipsoid, defined by the ellipse axes α' and γ'; this would be due to the predominance of a crystallographic plane, either as a growth face or as a cleavage plane. In other cases, the specimen might have a pronouncedly acicular habit with an ellipsoid axis α, β, or γ parallel to the elongation; or it might be optically uniaxial, in which case every grain would have one of its ellipse axes identical with the ω-axis of an ellipsoid of revolution. In such "two-dimensional" cases useful information about the unknown, of the nature indicated, may be obtained with the fixed stage adaptation of the polarizing microscope. Thus this adaptation is suitable for a considerable variety of work, and it is often sufficient for identifying unknown specimens by checking against tables of complete refractive index data published for known species.

In operating the fixed stage adaptation, one focuses on an immersed grain of the specimen between crossed polarizers, as usual, and then rotates the analyzer and eyepiece as a unit to one of the two azimuths in which the birefringent grain transmits light of the same intensity as the field. In this position the analyzer vibration direction is parallel to one of the two ellipse axes α' and γ' of the specimen and one can proceed with the refractive index comparison in the customary manner. Since precise settings of the analyzer are not generally required for refractive index measurements, this method is entirely adequate; it will be found especially exact if the crystal exhibits brilliant interference colors. If the specimen has a color of its own, as shown by examination with a single polarizer, then one should make the analyzer setting only after inserting a filter of the same color in the illuminator, or after selecting a grain so thin that its light absorption is negligible.

OTHER TYPES OF MICROSCOPE

From the foregoing the reader may have gained some suggestions for adapting other types of microscope than the standard medical instrument considered above. For example, the less expensive instrument known as the school microscope lacks substage condenser, iris diaphragm, and plane mirror, the concave mirror functioning as the lower element of a condenser. Obviously a sliding top condenser lens of the kind already described is necessary here if one desires to view complete interference figures. Also, in the absence of any other kind of diaphragm, an aperture plate over the illuminator will serve to cut down the illuminating cone as already described.

When one has to adapt a microscope equipped with a binocular body tube or inclined ocular tube for use as a polarizing instrument then the problem is often more difficult, because the prism systems here may introduce marked ellipticity in transmitting an incident linearly polarized beam. The position for the fixed analyzer is then narrowed down to the space below the prism system and above the objective, a considerably less convenient point than the eyepiece or the eyepiece tube. The same difficulty may be encountered in adapting an analyzer to a Greenough type of binocular microscope.

In conclusion, it seems to this writer that the adaptation of medical microscopes for use as polarizing instruments would be considerably facilitated if there were available a centerable graduated rotating stage, provided with a sliding top condenser lens, and suitable for clamping onto the top of any stationary stage.[2] Although it would not be difficult to add a fixed polarizer to such a unit, there is little to recommend this procedure.

[2] A sliding top condenser lens built into a fixed stage is illustrated in Hartshorne and Stuart's book (see bibliography) on page 112 (Swift "Lapidex" polarizing microscope).
A rotating stage superposable on a fixed mechanical stage is illustrated in STADE AND STAUDE, "Mikrophotographie," Akademische Verlagsgesellschaft, Leipzig, 1939, p. 46.

BIBLIOGRAPHY

(1) AMBRONN AND FREY, "Das Polarisationsmikroskop," Akademische Verlagsgesellschaft, Leipzig, 1926.
(2) CHAMOT AND MASON, "Handbook of chemical microscopy," 2nd ed., 2 vols., John Wiley and Sons, Inc., New York City, 1938.
(3) HARTSHORNE AND STUART, "Crystals and the polarising microscope, a handbook for chemists and others," Edward Arnold and Co., London, 1934.
(4) JOHANNSEN, "Manual of petrographic methods," 2nd ed., McGraw-Hill Book Co., Inc., New York City, 1918.
(5) LARSEN AND BERMAN, "Microscopic determination of the nonopaque minerals," 2nd ed., U. S. Government Printing Office, Washington, D. C., 1934.
(6) PRESTON, "Modern textile microscopy," Emmott and Co., Ltd., London, 1933.
(7) RINNE AND BEREK, "Anleitung zu optischen Untersu-

chungen mit dem Polarisationsmikroskop," Max Jänecke Verlagsbuchhandlung, Leipzig, 1934.
(8) SCHMIDT, "Die Bausteine des Tierkörpers in Polarisiertem Lichte," Friedrich Cohen, Bonn, 1924.
(9) WINCHELL, "The microscopic characters of artificial inorganic solid substances or artificial minerals," 2nd ed., John Wiley and Sons, Inc., New York City, 1931.
(10) WRIGHT, "The methods of petrographic-microscopic research," Carnegie Institution of Washington, Washington, D. C., 1911.

THE DEMONSTRATION OF AN INDUCED, OR COUPLED, REACTION

JAMES B. SUMNER

Biochemistry Laboratory, Cornell University, Ithaca, New York

DEMONSTRATIONS are sometimes difficult to conduct successfully and are not invariably illuminating or instructive even when successful. The coupled oxidation of carotene, which occurs when a trace of unsaturated fat, soap, or free fatty acid is peroxidized by lipoxidase,[1, 2] an enzyme abundant in soybean meal, makes a demonstration which is satisfactory in many respects. This demonstration illustrates:

1. Enzyme action.
2. The presence of double bonds in a fat.
3. Peroxidation of a fat.
4. An instance of an induced reaction.
5. The destruction of carotene by oxidation.

The directions are as follows:

Place 5 cc. of acetone-alcohol solution of crystalline carotene in a dry 250-cc. Erlenmeyer flask and 5 cc. in a second flask. To the first flask add a very small drop of cottonseed, hempseed, or raw linseed oil, or the respective soaps, or the free fatty acids. Mix, and then add to both flasks 100 cc. of water. Add 2 to 3 cc. of $M/2$ phosphate buffer of pH about 6.5. Now add 5 cc. of aqueous soybean meal extract and mix. The yellow color will disappear very rapidly from the flask to which the fat, soap, or fatty acid was added. The carotene in the second flask will undergo a slow spontaneous oxidation but some color will persist for as long as 24 hours.

In this experiment lipoxidase transfers molecular oxygen to the double bonds of the unsaturated fat, forming peroxides. In the act of forming the peroxides the carotene is somehow oxidized. Fatty acids which are already peroxidized have very little action upon carotene.

[1] SUMNER AND DOUNCE, *Enzymologia*, **7**, 130 (1939).
[2] SUMNER AND SUMNER, *J. Biol. Chem.*, **134**, 531 (1940).

PREPARATION OF REAGENTS

Carotene Solution.—Dissolve about 80 mg. of crystalline carotene (90 per cent beta and 10 per cent alpha) in 200 cc. of acetone and 400 cc. of alcohol.

Phosphate Buffer.—Mix 60 cc. of $2/M$ Na_2HPO_4 with 40 cc. of $M/2$ KH_2PO_4. The solution will have a pH of about 6.5 when diluted.

Lipoxidase Solution.—Mix 10 g. of defatted soybean meal with 100 cc. of water and centrifuge to clarify. The supernatant is employed. It will keep for a week or more if preserved with a few drops of toluene and kept in the ice chest.

THE COÖPERATIVE COMMITTEE ON SCIENCE TEACHING

UNDER the sponsorship of five scientific societies representing biology, chemistry, mathematics, physics, and research in science teaching a committee has been formed to work on educational problems of vital interest to all science teachers which no single organization can solve working alone. The committee is known as the Coöperative Committee on Science Teaching.

Two meetings have been held, one in April and one in November, 1941. Work is now in progress on four problems:

1. Licensing or certification of secondary-school science teachers. The committee hopes to work out a solution that will be practicable and that will be adopted by certification authorities.

2. The college training of prospective science teachers. It is desirable to prepare teachers for teaching certain combinations of subjects rather than to prepare intensively in one subject.

3. Exploratory studies of the secondary-school science curriculum. The Committee hopes to stimulate a number of colleges and universities to organize workshops and conferences for bringing together secondary-school teachers to work on their educational problems.

4. Problems of state or local agencies needing the services of educational consultants on questions pertaining to science teaching. The Committee offers its services as a consultant to state or local agencies working on problems pertaining to science teaching.

The Committee consists of the following members.

Representing the American Association of Physics Teachers: K. Lark-Horovitz, Purdue University; Glen W. Warner, Wilson Junior College, Chicago.

Representing the American Chemical Society: B. S. Hopkins, University of Illinois; Martin V. McGill, Lorain High School, Lorain, Ohio.

Representing the Mathematical Association of America: A. A. Bennett, Brown University; Raleigh Schorling, University of Michigan.

Representing the National Association for Research in Science Teaching: G. P. Cahoon, Ohio State University; Robert J. Havighurst, University of Chicago.

Representing the Union of Biological Societies: Oscar Riddle, Carnegie Station for Experimental Evolution.

Robert J. Havighurst is Chairman of the Committee and Glen W. Warner is Secretary.

Some Useful Expedients in Laboratory Glass Working

R. H. WRIGHT *University of New Brunswick, Fredericton, New Brunswick, Canada*

THE following glass-working tricks have been found very useful, and while they may have been used before they are not mentioned in any of the manuals of laboratory glass blowing with which the writer is familiar.

1. SECURING A SQUARE SEAL IN THE BORE OF A CAPILLARY TUBE

In sealing the end of the capillary tube of a McLeod gage or a high pressure manometer, and in various other connections, it is desirable that the bore of the capillary have a uniform cross section right up to the sealed end. When a capillary is sealed in the usual manner, the bore contracts to a conical point, such as is shown in Figure 1*A*. If, however, a slightly tapering glass rod is made by drawing out a larger piece, this can be thrust into the capillary until it sticks, and a little plug is then cut from it as shown in Figure 1*C*. By applying the flame of a blast lamp to the plugged capillary as is shown in Figure 1*D*, a square seal will be obtained with little or no distortion of the bore. See Figure 1*B*.

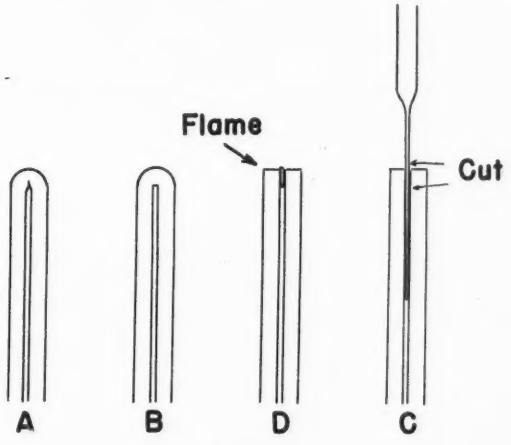


FIGURE 1

2. CLOSED CIRCUITS OF TUBING

In making manometers, McLeod gages, flowmeters, and other pieces of apparatus, a closed loop of tubing like that indicated in Figure 2 may be required. The methods of producing such a closed circuit usually recommended require that the piece be softened at two points simultaneously—an operation calling for considerable dexterity. The method suggested in Figure 2 avoids this difficulty. The two side tubes are sealed to the main tube and bent until their ends are properly aligned. The intervening tube which is to bridge the gap is cut to the correct length and held in place at one end by a short length of rubber tubing which serves also to seal the gap while the other end is being sealed in the flame. A bit of thin rod is useful in closing pinholes during the process. When one end is sealed, the rubber is cut away with a knife and the second seal is made, a thin rod being used to fill any gap that may have been left. The blowing is best done through a rubber tube attached at *A*.

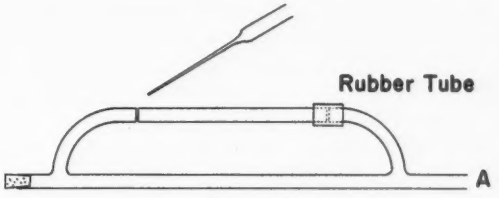


FIGURE 2

3. GROUND JOINTS

Although interchangeable ground joints are available in many sizes and are suited to many purposes, it is sometimes necessary to make a ground joint in the laboratory. The principal difficulties of the usual procedure are in retaining a true circular cross section while producing approximately the same taper in the two parts. These difficulties are avoided by using the procedure shown in Figure 3. A glass tube of the required size is supported near one end in a V-shaped cut in a board and at the other end by a one-holed rubber stopper held by a rod in the chuck of a variable

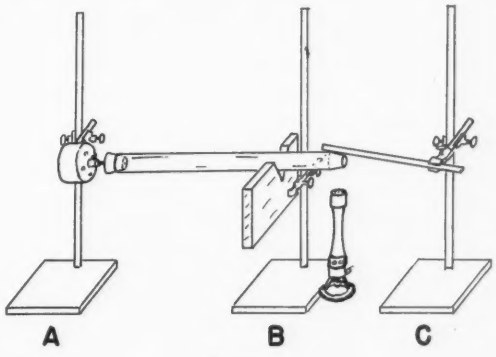


FIGURE 3

speed stirring motor.[1] The glass tube should be lubricated with a little glycerol where it rotates in the V-cut. A carbon rod, such as is used in arc lamps, is held

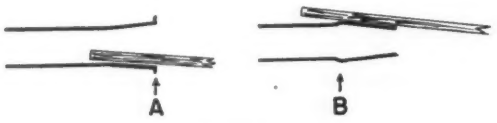


FIGURE 4

in a clamp at the angle desired for the ground joint, and at such a height that it presses either the outside or inside of the tube to be drawn down or flared. See Figure 4. The end of the tube for a length of several centimeters should be heated in the flame of a Meker burner while the tube is rotating at a moderate speed. When the glass begins to soften, the ring stand carrying the carbon rod is slid along the bench so that the rod slowly presses the glass to the proper taper. A blast lamp held in the hand may be used to supplement the Meker flame. In order to produce the flare shown at *A* (Figure 4) or the bulge shown at *B* (Figure 4) the speed of rotation of the tube is increased considerably and the blast flame played on the glass until it softens enough to be thrown outward by centrifugal force.

The success of the procedure depends on the fact that the angle at which the carbon rod is held is not altered by sliding the ring stand along the bench or by moving the clamp which holds the rod up and down on the ring stand. Grinding with glycerol and carborundum powder presents no particular difficulty because the two halves of the joint, if properly made, will have very nearly the same taper.

[1] The Model 3, Variable Speed Stirrer, made by the Eastern Engineering Company, New Haven, Connecticut, is very convenient.

SODIUM PERBORATE AS A REPLACEMENT FOR SODIUM PEROXIDE IN THE CHEMICAL LABORATORY

C. F. H. ALLEN and J. H. CLARK

Eastman Kodak Company, Rochester, New York

WHEN a vigorous oxidizing action is required in the chemical laboratory, sodium peroxide is one of the more useful reagents. Its drawbacks are well known, especially its hygroscopicity and tendency to start fires when in contact with readily inflammable materials.

While sodium perborate has long been known and readily available, it seems to have escaped notice that it can be successfully substituted for sodium peroxide in many oxidation reactions. This is probably due to the emphasis placed on its use in textile chemistry; practically all the abstract references are in this field. In the chemical laboratory sodium perborate offers nearly all the advantages of sodium peroxide with none of its drawbacks.

The two principal uses of the peroxide are: (*a*) in the inorganic analytical laboratory, where it is used in the analysis of the iron-aluminum group, and (*b*) in the organic laboratory for cleavage of α-diketones. Sodium perborate gives equally satisfactory results in both these instances, as shown in the examples below.

Sodium perborate has the formula $NaBO_3 \cdot 4H_2O$; the reagent grade has 9.5 per cent active oxygen. Thus, it requires twice the weight of the equivalent amount of sodium peroxide. The cost is in line, if the reagent is purchased in large enough quantities to secure the advantages of bulk buying. The solubility is somewhat less than that of sodium peroxide, but so much less than that of hydrogen peroxide that it cannot ordinarily be substituted for the latter in the organic laboratory. Further, it fails to replace sodium peroxide in the preparation of epoxides from α,β-unsaturated ketones.[1]

EXPERIMENTAL WORK

Inorganic.—In the separation of the iron and aluminum groups, the usual procedure is to oxidize the sodium chromite to chromate by cautiously adding solid peroxide to the *cold* solution. (It reacts explosively, if hot.) By the substitution of sodium perborate, the procedure is altered in but two respects: (*a*), use twice the weight of peroxide specified, and (*b*), heat the solution; the solid dissolves with vigorous evolution of gas.

The perborate is equally satisfactory when substituted for the peroxide in the separation of zinc, cobalt, and nickel.

Organic. Cleavage of Benzil to Benzoic Acid.—Ten grams of benzil were dissolved in 100 cc. of hot methanol. To this was added a suspension of 10 g. of sodium perborate suspended in 100 cc. of 5 per cent aqueous sodium hydroxide. The mixture was heated on a steam bath and stirred mechanically; after about fifteen minutes all the solid had dissolved. This solution was then transferred to a hot plate, evaporated to about half its volume to remove most of the methanol, cooled, and acidified to Congo Red with concentrated hydrochloric acid. The benzoic acid, which partially separated out as a white solid, was extracted with two 250-cc. portions of ether and the extracts were dried over sodium sulfate. Evaporation of the ether gave 9 g. (77 per cent) of benzoic acid, m. p. 120° to 121°.

[1] KOHLER, RICHTMYER, AND HESTER, *J. Am. Chem. Soc.*, **53**, 213 (1931).

Liebig and Proteins[1]

HUBERT BRADFORD VICKERY

Connecticut Agricultural Experiment Station, New Haven, Connecticut

PEOPLE today are far more conscious of the nature of their diet than they were a generation or so ago. To be sure, we have many accounts of the great feasts that passed as simple breakfasts or luncheons for our great-grandparents, and the menu for a dinner of the mid-nineteenth century is something that we look upon today with wonder and awe. But these records are actually in no way representative of what the average person habitually ate. Food was chosen, often, for its capacity to "fill one up," and little regard was paid to elementary principles of nutrition that are commonplaces in the knowledge of all but the most ignorant and underprivileged of the present generation of men and women.

It seems that chemistry teachers may well be interested in the events that have brought about this revolution in our attitude toward the food we eat, since the great changes that have occurred are largely due to the work of chemists. Like many changes, this one had small and obscure beginnings, and certainly none of the early workers could have foreseen the ultimate effects of the observations and experiments they made. However, a relation can be traced between the conditions in Europe in the early years of the last century that produced the great German investigator Justus von Liebig, and the fact that present-day fourteen-year-old boys are frequently six feet tall, while "petite" girls are now becoming rarer.

Just over a century ago, Liebig published a book that has had a most extraordinary influence on agriculture, the fundamental science that lies at the basis of food production. It was entitled "Organic Chemistry in Its Application to Vegetable Physiology and Agriculture," and, at the Philadelphia meeting of the American Association for the Advancement of Science, in 1940, the hundredth anniversary of its appearance was celebrated with a symposium on Liebig and his influence on contemporary and subsequent science. Liebig followed up this book with another on animal chemistry and, during the next three decades, published numerous papers, public letters, and texts in which he sought to show how science can be applied to the production of food materials, how these materials are utilized by the animal body, especially by man, and how disease can be controlled or mitigated by proper attention to diet.

Perhaps the most amazing thing about many of these publications is that they were frequently filled with errors. Liebig was not often at fault in his observations of the facts of nature, but his explanations and the inferences he drew from these facts were far too often colored by his enthusiasms and wishful thinking, to say nothing of his use of them in dialectic discussions in which the purpose was to demolish the adversary rather than to contribute to the truth. We accordingly have the almost unique phenomenon of a man who was often wrong stimulating discussion and investigation, contributing his vast mental powers and the resources of his great laboratory wholeheartedly and ultimately either finding the truth himself or forcing others to do so.

Liebig's influence on science extends in a very real sense to the present day. He was one of the first to establish a chemical laboratory in which students had the opportunity to carry out manipulations with their own hands. Previously, teaching was almost exclusively done by demonstration in the hands of the teacher and a chosen few assistants. It was he who promoted the manufacture and use of artificial chemical fertilizers, and every chemist has used a Liebig condenser and has carried out a combustion determination of carbon and hydrogen by some modification of Liebig's fundamental method. But, mainly, Liebig's influence is felt today through the work of the many men he trained to think clearly and logically, to experiment intelligently and accurately, to acquire facts. Although hypothesis and explanation follow naturally when one is in the possession of facts, they may or may not be correct. Liebig was quick to tear down these purely intellectual developments when they had been shown to be inadequate, and to replace them with views more nearly in accordance with newer and better supported knowledge.

The story of Liebig's association with the investigation of proteins illustrates well the way in which this man has reached out for a full century into the daily life of each of us. So far as one can tell from the meager records available, Liebig's attention was drawn to the study of proteins by the work of G. J. Mulder in Holland during the period from 1835 to 1840. Mulder had studied the chemical composition of silk, of gelatin, of egg white, and of the proteins of the blood, and had arrived at the conclusion that these substances were built upon a similar and quite simple structural atomic plan. Each of them was supposed to contain a chemical radical of identical structure with respect to the carbon, hydrogen, oxygen, and nitrogen atoms of which it was composed, and this radical was supposed to combine with sulfur and phosphorus in different proportions to yield these several natural substances. The radical was given the name "protein," a word derived from the Greek for "to take the first place"; the radical was thus the fundamental substance of nature, the substance first formed in the egg from which animal life originates. Mulder further assumed that protein was derived by the animal from the

[1] Presented at the third Summer Conference of the New England Association of Chemistry Teachers, Storrs, Connecticut, August 13, 1941.

vegetable food that it ate. He said, in his first paper on the protein hypothesis

"This is the nutritive material of the entire animal kingdom, and is probably prepared only by the plants."[2]

JUSTUS VON LIEBIG

To Liebig's vivid and fertile imagination this was a most illuminating statement. He eagerly sought for evidence in its favor, and within a year or so had convinced himself that the typical proteins of the animal world had their counterparts in the plants; he defined animal casein, animal gelatin, animal fibrin, and animal albumin as the four kinds of protein present in animals, and asserted that plants also contained these four substances as well, referring to them as plant casein, plant gelatin, and so forth. He maintained that the animal obtained its protein ultimately from a diet of vegetable substances, which it secured either directly, or indirectly through the bodies of other animals. The protein was used unaltered for the preparation of blood, since to Liebig the circulating blood was the truly representative animal material.

In this first rush of enthusiasm, Liebig committed himself to a series of hypotheses and explanations which were soon shown by experiment in his own laboratory, as well as in those of others, to be incorrect. By 1845, he had become convinced that the whole concept back of Mulder's "protein hypothesis" was wrong—that is, the view that there is an identical radical common to all these substances. His repudiation of this view, and the defense of it by Mulder, was one of the most distressing incidents of either of their lives and reveals an aggressive and uncompromising side to Liebig's character that is far from attractive.

Liebig and his students had found that the most helpful manner in which to study the composition and structure of proteins was to decompose them with powerful reagents into simple substances that could be readily recognized and identified. These simple substances must then represent fragments of the original protein molecule, and their nature must reveal the nature of portions, at least, of the molecule from which they were derived.

Although this idea, too, was not entirely original with Liebig, it was first prosecuted on a clear and logical basis by him, and the fact that he failed to get very far with it is probably largely due to the chance that he selected what later developed to be the wrong reagents to decompose the proteins. Being fundamentally interested in oxidation reactions, and having himself discovered aldehydes, a new class of organic compounds, by their use, he subjected proteins to oxidation under somewhat extreme conditions. Liebig felt himself richly rewarded when he found that the products were a series of common fatty and aromatic organic acids, together with his old friends the aldehydes. This was indeed a fundamental accomplishment, since it showed for the first time that the proteins contained atomic groupings of a familiar type in appreciable proportions. That it failed to give a very accurate idea of the chemical nature of proteins was simply because the decompositions went so far that the groupings which are indeed characteristic of the protein molecule were themselves destroyed. The reagents were too powerful; too many other kinds of organic substances could give exactly the same type of product for the results to indicate clearly the true nature of the atomic groupings in the protein.

Liebig's personal concern with protein chemistry lasted only a few years. During this period, he discovered the amino acid tyrosine, and brought about the destruction of the original "protein hypothesis" of Mulder by showing that it was not in accordance with the experimental facts. But he had the perspicacity to preserve the concise and non-committal word "protein" as a general term to be employed instead of the cumbersome "albuminous body" or "albuminoid," with its connotation of relationship to the white of egg. In addition, he showed that the direction of true progress lay in the study of decomposition products of proteins, and he raised the fundamental question of the fate of proteins when ingested by the animal, pointing out that the intermediary metabolism of proteins is really the problem with which protein chemists must be concerned.

Lastly, he trained a number of brilliant and gifted students who carried on the work where Liebig himself left off, and it is because of the work of these students, and in turn of their students, that I feel that the work of Liebig may have some interest today.

There is the example of his student Bopp, who turned from strong oxidizing reagents and alkali fusion to the

[2] *Natuur- en scheikundig Archief*, 6, 128 (1838).

use of hydrolysis in the decomposition of proteins, and was at once rewarded by the discovery of a clean and easy way to prepare tyrosine. But of more outstanding importance was Heinrich Ritthausen. Ritthausen apparently spent only a limited period with Liebig, and in 1853 was an assistant to Erdmann in Leipzig. He moved from there to the tiny Agricultural Experiment Station at Möckern, founded two years previously as the first experiment station in the world to be supported by the taxpayer and farmer. Here he became interested in the composition of animal fodders and other agricultural products and soon encountered difficulties with the nitrogenous substances all of these materials contained. In several successive posts in experiment stations he continued this type of investigation, but at last in 1857, at Waldau, the chance was presented to begin a logically planned series of investigations into the most important type of vegetable proteins, the proteins of seeds. Publication of his first paper on this subject was delayed until 1862, an interval that gives some idea of the time it took to develop experimental methods and technic. His first paper dealt with the proteins of wheat flour, the most important of all vegetable proteins. From then until his retirement in 1899, scarcely a year passed without the appearance of one or more papers on some phase of protein chemistry. Taken together, these papers represent one of the greatest monuments to industry, patience, care, and devotion to a single theme that chemical science possesses. In the protein field there is only one other parallel case, to which I shall refer in a moment.

His contemporaries for the most part failed entirely to grasp what Ritthausen was trying to do, and his work was subjected to severe criticism. He was compelled to spend much time in polemical discussions and in demonstrations that his results were, in fact, fundamentally sound. Nevertheless, as Osborne wrote in an obituary notice in 1913,[3]

"Little attention was paid to this later work, although his papers were filled with information that has proved more helpful in developing our present knowledge of the chemistry of proteins in general than has most of that furnished by his critics."

Ritthausen's accomplishments were: first, the discovery of glutamic and aspartic acids as products of the hydrolysis of proteins; second, the realization that hydrolysis is the only method of decomposition of proteins that leads to decomposition products truly characteristic of the original protein molecule; third, the statement that these decomposition products are amino acids, which are formed in proportions characteristic of the particular protein from which they are derived—this statement laid the foundation of our present-day methods of amino acid analysis of proteins; and, fourth, the statement that if proteins differ in amino acid composition, they should also differ in nutritive value to the animal. In addition, he described a wide array of proteins derived from various seeds, showed how they could be prepared in relatively pure form, and furnished analyses of hitherto unexampled accuracy for the elements carbon, hydrogen, nitrogen, and sulfur.

In 1872, Ritthausen summarized his researches to date in a small book,[4] published at Bonn, that is still a source of admiration, not to say inspiration, to all who have the patience to read what we are now too apt to regard as antiquated science. It was this book that won him his promotion to the chair of chemistry at Königsberg where he spent the rest of his active life, and it also furnishes one of the strong links that bind the work of Ritthausen to present-day protein chemistry. I wish to follow this connection in some detail.

In order to do this, we must return to the academic year 1853–54. Samuel W. Johnson, who had studied chemistry at Yale under J. P. Norton, himself a pupil of Mulder, spent this year in Germany working in analytical chemistry under Erdmann at Leipzig. While there he made the acquaintance of the young Heinrich Ritthausen, either in the laboratory at Leipzig, or at the nearby experiment station at Möckern, which he visited because of his fundamental interest in the application of chemistry to agriculture. Johnson mentioned the young chemist at Möckern in a brief article he contributed to *The Country Gentleman* in February,

SAMUEL W. JOHNSON

1854, in which he described the new institution devoted to agricultural science. This visit to Möckern must have had a profound influence on Johnson, for

[3] *Biochem. Bull.*, **2**, 335 (1913).

[4] "Die Eiweisskörper der Getreidearten, Hülsenfrüchte und Ölsamen," Verlag von Max Cohen und Sohn, Bonn, 1872.

from that time the one idea that he wrote about and talked about, whenever an opportunity presented itself, was the desirability of establishing similar institutions in this country. We largely owe the Agricultural Experiment Stations, found in every state in this country, to the ideas acquired and later developed by this one man during his sojourn in Germany in the years 1853 to 1855.

Johnson spent one year with Erdmann at Leipzig, and then applied for admission to the new laboratory Liebig had established at Munich. He soon gained Liebig's friendship and, in addition to taking his share in the daily work of the laboratory, was asked to prepare the English translation of one of his teacher's important polemical papers,[5] the one in which Liebig attacked the agricultural work of J. B. Lawes at Rothamsted. This paper was published at Albany in 1855.

After his return to this country, Johnson taught chemistry at Yale for many years. He was appointed to the chair of agricultural chemistry in 1857 and interested himself in the cause of agriculture. Through his connection with the Agricultural Society he became one of the leading spirits in the promotion of the application of scientific methods on the farm, and finally, in 1872, began the series of carefully planned steps that led to the recognition by the federal government of the desirability of the establishment of state institutions for the scientific study of agriculture. In 1875, the Connecticut station was formally launched by the appropriation of a small sum of money by the Connecticut legislature for the period of two years, to be expended at Wesleyan College in Middletown for "employing competent scientific men to carry on the appropriate work of an Agricultural Experiment Station." Two years later, the trial period having shown the great advantages to agriculture of this institution, the legislature reorganized the station and set it up as a permanent state activity with Johnson as its director; land and buildings were acquired in New Haven and occupied for the first time in 1882. In 1887 the federal government passed the Hatch Act, under which funds were granted for the establishment of similar institutions in each state, with the specific duty "to conduct original researches or verify experiments on the physiology of plants and animals."

Johnson's personal activities were for many years largely of an administrative nature. There was little time for the pleasures of research, but he retained his youthful interest in the progress of science and became, through his reading, a master of the chemical and agricultural literature who has had few equals. This is vividly shown by the little book, "How Crops Grow," which he published in 1868. This book is really a development of the lectures on agriculture he had given at Yale for many years. It became at once a standard text and was translated into many foreign languages. In 1890, it was revised and brought up to date and had many years of popularity.

The significance of this book, in the present discussion, is chiefly due to the section on the proteins. The 1890 edition contains a discussion of these substances that is by far the most thorough and penetrating that had appeared anywhere, and this section remained the best textbook discussion of the subject for nearly two decades. It will be recalled that the work of Ritthausen in Germany had been subjected to adverse criticism, as a result of which the leaders of physiological chemistry in that country had largely ignored his remarkable contributions. Johnson had the perception to see that what Ritthausen had done was by far the best work that had been published in the field, and he gave a clear summary of Ritthausen's results. It is obvious that Johnson was one of the few men who had read all of Ritthausen's voluminous papers, and had understood what they meant. Further, he must have thought deeply about the subject, for he saw that the results, important as they were, were inconclusive and incomplete. More extensive and detailed investigation was clearly essential, and in 1888, Johnson took a step that turned out to be one of this remarkable man's greatest contributions to science.[6] The acquisition of federal funds under the Hatch Act, together with the obligation defined in this Act to carry out "original researches," opened the way to the establishment of a long-time research project that did not necessarily provide immediate returns of a practical nature for the benefit of the farmer. Johnson must have surveyed the field of possible problems with the most careful thought. His final selection of a project is an evidence of knowledge and foresight that is rare indeed. One day in August, 1888, he turned to his assistant and son-in-law, Thomas B. Osborne, and asked him if he would care to undertake an investigation of the proteins of plant seeds along the lines of the studies still being carried out at Königsberg by Ritthausen. The problem was to be Osborne's own, and he was to devote his entire time to it, being relieved from the routine analytical work of the laboratory.

The series of investigations that was thus begun at the Connecticut Agricultural Experiment Station continued unbroken for forty years. Osborne published, in that period, about 250 papers, reviews, and other articles, including a small monograph[7] that is still the most complete and authoritative discussion of the vegetable proteins. He had the satisfaction of seeing protein chemistry develop from an obscure and difficult topic on the borderland between organic chemistry and biology—with which even his closest chemical friends had little or no patience and certainly no understanding—into one of the major branches of biochemistry.

Osborne's first ten years of investigation were spent

[5] LIEBIG, "The relations of chemistry to agriculture, and the agricultural experiments of Mr. J. B. Lawes," translated by SAMUEL W. JOHNSON, Luther Tucker, office of *The Country Gentleman*, Albany, N. Y., **1855**.

[6] VICKERY, "The influence of Samuel W. Johnson on the chemistry of proteins," *Yale J. Biol. Med.*, **13**, 563 (1941).

[7] OSBORNE, "The vegetable proteins," Longmans, Green and Co., London, **1909**; 2nd ed., **1924**.

in the preparation of as many of the proteins of economically important seeds as possible. These substances were purified as completely from other contaminating substances as available methods permitted, and were subjected to the closest chemical examination. In looking back over these papers, it is interesting to see in the selection of the very first subject of study, the oat seed, the thread of continuity with the past. It happens that Johnson's teacher at Yale, J. P. Norton, had studied at Edinburgh from 1844 to 1846 under the celebrated Scottish agricultural chemist James F. W. Johnston, and had investigated the chemical nature of what today we should call the proteins of oatmeal. These preparations were taken by Norton to Holland where he went in 1846 to study with Mulder. Norton prepared an essay on his oat investigations for a prize offered by the Scottish Agricultural Society, and was successful in winning the award. With this background, he returned to teach at Yale where Samuel Johnson was one of his pupils, but the oat seed investigation was not continued very far because of Norton's early death. However, when Johnson discussed the matter of seed protein investigations with Osborne thirty-five years later, the old work of Norton on the oat proteins was recalled and also, in part because this seed had not been studied by Ritthausen, the decision was made to begin with it.

At the turn of the century, protein chemistry was converted, by the classical researches of Emil Fischer, from an activity that had attracted not more than four or five first-class minds in the whole world during a period of fifty years, into a field of organic chemical research that aroused immediate interest everywhere. In addition, a theoretical approach to the problem of protein structure was provided by Hofmeister. Fischer, in a series of outstanding papers, discussed the optical activity of the amino acids and showed how inactive synthetic amino acids could be resolved to give optically active substances identical with those yielded by the proteins on acid hydrolysis. He also showed that amino acids could be converted into their esters, which were volatile substances that could be distilled, and, most important of all, demonstrated that the mixture of esters obtained from the protein could be separated by distillation into fractions so simple that the individual substances could be recovered with some approach to quantitative accuracy. A great light was at once thrown upon the nature of the proteins. They were clearly complex substances composed mostly, if not exclusively, of amino acids linked to each other by bonds, that came to be called peptide bonds, which are of the nature of substituted amides. Fischer prepared many artificial peptides to illustrate this point. Meanwhile the physiological chemist Kossel was developing the methods to determine the three basic amino acids of proteins, and one of Hofmeister's students, Hausmann, had shown that it was possible to determine the relative proportions of the different forms of nitrogen in proteins with relative ease.

Osborne was thus, all at once, provided with new methods with which to characterize the many proteins he had prepared, and for the first decade of the present century he devoted the entire resources of his laboratory

THOMAS B. OSBORNE

to the problem of protein characterization. He succeeded in showing that each individual protein was different in some respect from the others; that is, that they are specific substances. He thereby disposed forever of Liebig's old idea that there are only a few proteins in nature. He made amino acid analyses of proteins, more complete than even Fischer himself was able to achieve, and laid the fundamental chemical groundwork for the study of the old problem first propounded by Ritthausen: whether or not proteins from different sources differ in their nutritive effects upon animals.

It is this phase of Osborne's work that has brought the results of the chemical study of proteins into the daily consciousness of everyone. Together with Mendel of Yale, Osborne tried the effect of protein after protein upon the rate of growth of rats. The first efforts failed completely because the animals, placed upon diets composed of pure protein, fat, starch, and mineral salts, promptly died. Study of the details of the diets revealed that some essential and hitherto overlooked constituent was being omitted, and when it was found that this constituent was present in butterfat, the way was paved for the discovery of vitamins. Osborne and Mendel's discovery of the essential nature of some unique constituent of butterfat, present in amounts that could be described only as traces, was anticipated by a few weeks by the publication of McCollum that described the first clearly recognized, fat-soluble, accessory food factor or vitamin. However, their paper was at once recognized as being far more

conclusive and the new concept of vitamins was soon universally accepted. Within a few years evidence for the existence of at least three different vitamins had been obtained in various laboratories and today we have nearly a dozen, the chemical nature of which is well understood.

With a technic of animal feeding once firmly established, Osborne and Mendel proceeded to the comparison of the proteins, one with another. It soon developed that one protein was, in fact, not the equivalent of another in nutrition. Certain proteins were found to be almost, if not entirely, useless to the animal when administered alone in a diet otherwise shown to be adequate for growth. Here the toilsome years spent in the amino acid analysis of proteins proved to have been time well spent. The deficiencies in these certain proteins could in each case be referred to a deficiency in one or more of the amino acids. If these substances were provided, together with the deficient protein, normal growth occurred. Three different amino acids were recognized to be essential in the diet—lysine, tryptophane, and cystine. Without an adequate supply of each of these no animal could live.

In recent years, the list of essential amino acids has been greatly extended. There are ten of these substances that are now known to be required in the diets of growing rats, and one of the substances recorded by Osborne and Mendel, cystine, has now been shown not to be required. This was not a mistake on their part. The error arose from the use of casein, a protein notably deficient in cystine, in the experimental diets. When this protein was fed at low levels, the animals failed, and the failure was at the time attributed to the lack of cystine, since when cystine was added to the casein diet a response occurred. Actually, however, in this case the animals failed because of the lack of another sulfur-containing amino acid, methionine, that was not discovered to be a constituent of proteins until 1922,[8] many years after Osborne and Mendel's work was done.

The two outstanding achievements of the nutrition work of Osborne and Mendel—the recognition of the existence of vitamins, and the discovery that certain amino acids are essential constituents of the animal diet—complete the thread of historical relationship between the work of Liebig and what is the common knowledge of everyone today about the science of nutrition. Doubtless the younger among my readers were fed, in babyhood, with orange juice and cod-liver oil. They may or may not recall having appreciated these additions to their early diet; but they benefited from research carried out by protein chemists who in their own early youth had no such advantage.

Liebig, by his scientific enthusiasm, his gift for publicity, and his conviction that a broad knowledge of science and of its application to agriculture is essential to human progress, started a train of events the ultimate consequences of which we are still unable to visualize. He may have been, and often was, at fault; but his errors were truly great ones in that they stimulated research that finally led to truth. During the hundred years since he occupied himself with the study of proteins, there has been continual progress; each step and each accomplishment have led to something new and valuable, and each has been made the basis for ever accelerating advance. Osborne died in 1929, only twelve years ago, and he had seen proteins become one of the major topics of modern biochemistry as it is taught in every graduate school. Yet so much has happened in the brief time since that I am convinced that, were he to return for a day, he would be completely bewildered by the technical terms, the new concepts, and new technics that are glibly discussed by every young student of the present. But he would fully appreciate what has been accomplished in the spreading of this enlarged and more accurate knowledge of nutrition; he would at once grasp why boys and girls alike are bigger and healthier than they ever were before, and he would readily understand the progress in the dairy and poultry industries that has come about. I suspect that he would be somewhat indignant at the prostitution of scientific knowledge in the current advertising of vitamins in everything from face powder to tobacco, and I should dearly love to listen to his reaction when he first heard the radio announcer describe the benefits to be received from the "vital ten protein elements" in a widely advertised breakfast food. On the whole, however, he would have every reason for deep pride in the results of his own work, and in the wisdom of Samuel Johnson, the pupil of Liebig, whose perspicacity and foresight made possible the further development in the laboratory in New Haven.

During the period since Liebig worked with proteins there have been many changes. A century ago the distinction between atom and molecule was vague, analytical methods were seldom adequate, and Liebig himself made what was probably the most significant advance in this field when he devised the combustion method for hydrogen and carbon. Since that time, and particularly in recent years, advance in our knowledge of the proteins has been rapid indeed. The men whose work I have outlined were among the small group who did most to bring about this advance. There is no doubt that the revolution in thought occasioned by Fischer's advent into the field was the most important single factor, since for the first time a theoretical approach to the problems became possible, and the way was opened to the application of powerful physico-chemical methods for the solution of these problems. Today the physical chemists have provided us with a conception of protein molecules of a definite size and shape, a shape that has recently been verified through the application of the electron microscope,[9] with a definite distribution of electrical charges upon which such properties as solubility and behavior in the electric field depend, and even with methods whereby

[8] MUELLER, *Proc. Soc. Exptl. Biol. Med.*, **19** 161 (1922); *J. Biol. Chem.*, **56**, 157 (1923).

[9] STANLEY AND ANDERSON, *J. Biol. Chem.*, **139**, 325 (1941).

proteins can be prepared in truly pure form. This last has until very recent years been an ideal that we have been able only to approach. Today the field of protein chemistry is one of the most active in biochemistry; a recent volume (139) of the *Journal of Biological Chemistry* contained 101 papers of which 37 dealt with proteins, amino acids, and related subjects. In 1929, the year of Osborne's death, the proportion (in Volume 82) was 25 per cent, while in 1920 (Volume 42) it was only 17 per cent. So striking an increase as this in general interest in proteins among professional chemists suggests that the time is soon coming when the layman's interest will likewise be aroused, and this thought, in turn, has its significance for the teacher of chemistry. It would seem that this subject which, only a few years ago, was regarded as one of the more abstruse branches of graduate school study, is rapidly becoming one with which teachers at the lower levels must concern themselves. If our boys and girls are to be exposed to the superficial and frequently ill-informed statements about science and medicine made over the radio and in the daily press, it is desirable, if not necessary, that some corrective in the form of accurate factual information be provided in the schools. Although this is not a plea that chemistry teachers should at once introduce the study of proteins into their curricula, it is a suggestion that they should at least inform themselves and become prepared to answer questions and counteract the effects of misinformation.

What's Been Going On

(*Continued from page 52.*)

cadmium red pigment is cadmium selenide. Selenium products are used as antioxidants in lubricating oils and impart extreme pressure resistance to the oily film. Selenium derivatives are used in the selective oxidation of organic compounds, as well as for dehydrogenation, and selenium dioxide is used as a catalyst in Kjeldahl determinations. The problem of selenium poisoning of animals feeding on seleniferous plants on the great plains was discussed. A few species of plants cannot survive except on selenium-containing soils and may be used as "indicators" in locating such soils.

The chemistry of the crystalline and glassy molecularly dehydrated phosphates was reviewed, and the large-scale uses of metaphosphates in water softening and in the stabilization of dilute supersaturated solutions of lime were pointed out. Calcium metaphosphate is being experimented with as a fertilizer.

Precipitated tricalcium phosphate always has the composition, $3(Ca_3P_2O_8)\cdot Ca(OH)_2$, a hydroxy *apatite*. It is used as an abrasive, in tooth cleaning preparation, and as a "conditioner" for table salt and sugar, to prevent caking. The compound enters into basic exchange reactions and may be used to remove fluorides from drinking water:

$$3(Ca_3(P_2O_8))\cdot Ca(OH)_2 + 2NaF \rightarrow 3(Ca_3(P_2O_8))\cdot CaF_2 + 2NaOH$$

The absorbent can be regenerated. The same material may be used to remove free fatty acids from oils and thus finds applications in refining vegetable and mineral oils.

Commercial trisodium phosphate (T.S.P.) always contains excess free alkali and is best represented by the formula $9(Na_3PO_4\cdot 12H_2O)\cdot 2NaOH$. This salt forms a series of isomorphous double salts containing, among other substances, $NaMnO_4$ and NaClO. Mixtures of T.S.P. with $9(Na_3PO_4\cdot 11H_2O)\cdot 2NaMnO_4$ and $4(Na_3PO_4\cdot 11H_2O)\cdot NaOCl$ are used as sterilizing detergents and water softeners. The permanganate type is used to color the product so that the cook will be sure to use it in the dishwater rather than in the cake. Another double salt, produced by dehydrating the gel formed between ferric and sodium pyrophosphates, has the composition $Na_9Fe_4(P_2O_7)_5\cdot 6H_2O$. It can be used in food fortification, because it does not promote rancidity (in flour) as do ordinary iron salts.

$(NH_4)_6P_6O_{15}N_2$, ammonium hexaphosphate dinitride, produced from P_2O_5 and NH_3, is useful in sequestering calcium ions, soap assisting, emulsifying, and fire-proofing.

Powdered calcium acid phosphate, $Ca(H_2PO_4)_2$, is coated with a complex phosphate by evaporating a solution of potassium and aluminum phosphate solutions on the surface and fusing the adhering powder at a low temperature. The rate of reaction with water of baking powder, prepared from this coated acid phosphate, is retarded, improving its leavening qualities.

Zinc oxide pigment is coated with a complex phosphate, to inhibit reaction of the pigment with the vehicle.

Case hardening of steel by *nitriding* is accomplished by heating certain steels in ammonia at 960°–975°F. The steels contain aluminum and chromium. A remarkably high surface hardness is obtained, which is retained up to 1100°F. The tensile strength of the core metal is simultaneously improved by the heat treatment. Little shrinkage accompanies the treatment and the article can be brought nearly to size before nitriding, and then lapped to the final dimensions. This process is used to finish gears, bushings, knuckle pins, cylinder barrels for airplane motors, and so on.

The latest addition to the hard carbides is tungsten titanium carbide, $WTiC_2$. Tools are produced by attaching hard cemented carbide inserts for the working edge to the holder by copper brazing. The use of inserts represents a great reduction in the requirement of tungsten for tool steels and produces cutting edges which retain their keenness at red heat. The hard carbides are produced by dissolving the constituents in a metallic solvent like molten aluminum, which is later removed by reacting with acid. The insert is prepared by "powder metallurgy" by sintering a mixture of the hard carbide with cobalt. The recent developments in these new cutting edges for tools are bound to have far-reaching significance in the present war.

Recently sodium chlorite, $NaClO_2$, has become commercially available. It produces superior bleach solutions for cellulose materials, in that the fabric is strengthened rather than weakened in the process. Mixtures of chlorite and hypochlorite are used in bleaching textiles and paper pulp. Due to the possibility of producing dangerous concentrations of ClO_2, care must be exercised in using chlorites.

The quantity of perchlorates produced has in the last few years increased rapidly. While many are familiar with the advantages of perchloric acid in analytical work, the commercial application of perchloric acid and its salts is much less familiar. From it are produced safe explosives for use in mines (Cardox system), and railroad and aviation signaling devices. In electroplating and electromining, solutions of perchlorates have many advantages, chiefly due to the great stability of the perchlorate ion and the freedom from gaseous products. Magnesium perchlorate is important in improving the efficiency of liquid air plants, where it enters in the final drying of the incoming air to zero moisture. One of the by-products of the manufacture of perchloric acid is nitrous oxide, N_2O, which is sold almost exclusively in ready-whip bottles for whipped cream, commonly seen now at soda fountains.

—LAURENCE S. FOSTER

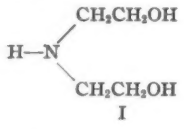
The Ethanolamines

CHESTER B. KREMER

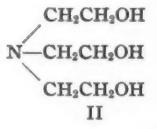
The City College, The College of the City of New York, New York City

IN THE ethanolamines, the chemist finds another example of chemical substances which, just laboratory specimens at first, are today of great practical importance. So diversified and numerous are the uses of these materials that it would take many pages fully to outline all their applications. This article will touch only upon comparatively few of the more common or interesting uses.

The ethanolamines are the simplest members of that group of organic compounds known as amino alcohols. They were first synthesized (*1*) in 1862 when a German scientist reacted ethylene oxide with ammonia under pressure and, after fractionation of the resulting liquid, obtained a few grams of a strongly alkaline, water-white liquid, somewhat ammoniacal in odor. Analysis proved it to have the formula $NH_2CH_2CH_2OH$ and it was given the name "colamine." From the reaction mixture two more distinct compounds were obtained, one boiling at 268°C. and the other at 195°C. (under 10 mm. pressure). The chemical reactions of these two products showed them to be closely related to colamine and their structures were soon proved to be:



I



II

Since the three substances differed from one another in the number of ethanol ($—CH_2CH_2OH$) residues, they became known as monoethanolamine (formerly called colamine), diethanolamine (I), and triethanolamine (II). As a group, they are today called the ethanolamines.

Since the ethanolamines are alcohols as well as amines, their adaptability is based upon the properties of both classes of compounds. When to these are added the specific properties of each molecular substance, it is not difficult to understand their versatility.

Perhaps one of the most common uses of the ethanolamines in industry is their use as gas absorbers (*2*); in this instance, advantage is taken of their basic properties. Either the mono-, di-, or triethanolamine can be employed; all are capable of absorbing large quantities of an acidic gas. Carbon dioxide, for example, is readily taken up and any non-acidic gas contaminated with CO_2 can be freed of this constituent merely by bubbling the mixture of gases through the ethanolamine. On heating the solution, the carbon dioxide is freed from combination and the amino alcohol can then be used again to absorb fresh quantities of gas.

In the dry cleaning industry, triethanolamine soaps are of great practical importance (*3*). Ordinary soap is a salt formed by the combination of a base (usually sodium or potassium hydroxide) with a fatty acid (such as stearic or palmitic acids). Using triethanolamine as the reacting base, instead of potassium or sodium hydroxide, results in the formation of a triethanolamine soap.[1] These soaps are soluble in ordinary dry cleaning solvents such as xylene or naphtha. A dry cleaning solvent incorporating such a soap exhibits, in addition to its usual solvent action, the emulsifying action of the organic soap. Thus the volume of solvent required in a given cleaning is materially reduced and a corresponding saving is effected.

The use of simple compounds derived from the ethanolamines is widespread in the field of cosmetics (*4, 5, 6*). In the main, these compounds are used as emulsifiers. Practically all cold, cleansing, and vanishing creams are emulsions of oil or oily materials in water. However, in order to prepare emulsions of this type, a third substance must be present to keep the emulsion from separating. Separation occurs when the tiny droplets of dispersed material come together to form increasingly larger and larger drops until finally the oil separates completely and floats on top of the water. To prevent this separation an emulsifying agent, such as an ethanolamine soap, is added to the starting materials. Triethanolamine soaps are ideal emulsifying agents for cosmetic preparations because of their complete lack of alkaline irritation effect. Moreover they aid in the absorption of various oils by the skin and are external antiseptics. A typical cleansing cream is one made of stearic acid, lanolin, mineral oil, triethanolamine, water, and terpineol. The latter is added to mask the odor of lanolin. Perfumes and agents to retain the moisture of the emulsion are invariably added.

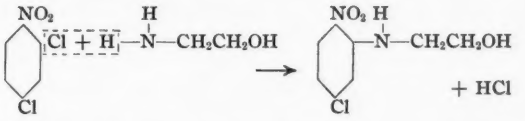
Not only certain derivatives of the ethanolamines, but the ethanolamines themselves find valuable use in the cosmetic industry. Thus, materials used in the permanent waving of women's hair contain monoethanolamine. The latter is used here chiefly as a source of ammonia. Ordinary ammonia in solution is difficult to employ because it is so easily lost when the solution is heated. Monoethanolamine, however, gives off ammonia slowly when heated, due to decomposition of the molecule. This slow process assures the presence of the latter ingredient during the entire operation.

Of passing interest is the use of the ethanolamines in depilatories. Their function here is that of a solvent, it having been established that the sulfur compounds employed in depilatories are much more soluble in a base cream incorporating the amino alcohol.

---

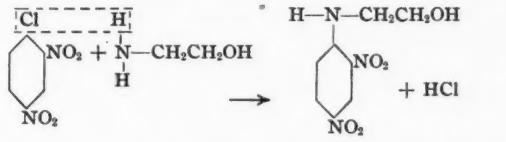
[1] Water is not split out in the formation of the triethanolamine soap.

Perhaps the three most interesting uses of these amino alcohols are their applications in the production of dyes, drugs, and explosives. When cellulose acetate and cellulose nitrate silks began to attain the importance they now hold in the textile world, it was evident that a new branch of dye chemistry would have to be evolved. Many of the dyes previously developed for the dyeing of natural silk were found to be useless when applied to acetate or nitrate silk. Research soon developed new dyes for these silks, in the synthesis of which the ethanolamines played a prominent role (*7*, *8*). A valuable cellulose acetate dye, for example, is synthesized from 2,4-dichloronitrobenzene and monoethanolamine as follows:

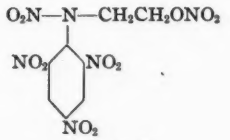


This dye, 2-(5-chloro-2-nitroanilino)-ethanol, in which the only chromophore group is the nitro group on the benzene ring, imparts a yellow color to cellulose acetate silks. An entire series of these compounds, differing in substituted groups, have been synthesized and have found application as dyes.

The use of monoethanolamine in the synthesis of certain explosives is of increased interest due to war conditions existing today. The best known explosive of this type is called "Pentryl" (*9*), an appreciably more powerful explosive than TNT (trinitrotoluene). Its chemical name is *sym*-trinitrophenylnitraminoethyl nitrate. The product is synthesized in two stages. First, 2,4-dinitrochlorobenzene is condensed with monoethanolamine to give 2-(2,5-dinitroanilino)-ethanol:



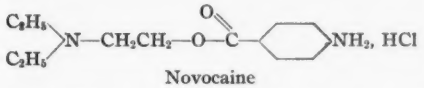
Then this product is nitrated with nitric acid to give Pentryl:



Pentryl

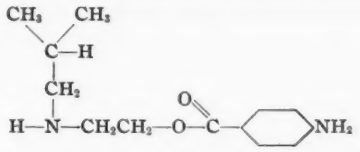
In the field of physiologically active compounds, the ethanolamines (as well as many amino alcohols) play a most important role. Here, however, it is not the simple amino alcohol, but rather a derivative of this substance that is of importance. In this short article, only two of many important illustrations will be given—both in the field of local anesthetics.

The most widely used of all local anesthetics is the compound novocaine, which is synthesized from an ethanolamine derivative, diethyl aminoethyl alcohol. Novocaine is prepared by treating this latter substance with *p*-nitrobenzoyl chloride, thus forming diethyl aminoethyl *p*-nitrobenzoate. This is then reduced to give diethyl aminoethyl *p*-aminobenzoate. The hydrochloride of the latter is known as novocaine.



Novocaine

While novocaine is widely used, it is far from the ideal anesthetic because of its lack of pressor action. For this reason, novocaine is often mixed with adrenalin before injection, the latter acting as a vasoconstrictor. A tremendous amount of research has been carried out in an effort to produce a local anesthetic which, in the same molecule, will exhibit both anesthetic and pressor action. Recently some success has been attained and once again the ethanolamines play a leading part (*10*, *11*). From monoethanolamine, a derivative with a mono alkyl substitution on the amine nitrogen was synthesized, and this was then condensed with *p*-nitrobenzoyl chloride and the resulting product reduced as in the production of novocaine. This compound, *iso*-butylaminoethyl *p*-aminobenzoate, exhibits not only pronounced anesthetic properties, but pressor action as well. The formula of this compound is:



Thus today it is not suprising to find the ethanolamines highly valued for commercial use. New uses for these compounds and their derivatives are constantly being found. Few chemicals have, in such a short time, attained as general a use as the ethanolamines which, from their start in test tubes, now are shipped across country in tank cars.

LITERATURE CITED

(1) WURTZ, "Ueber die Oxyathylenbasen," *Ann.*, **121**, 226 (1862).
(2) FRYDLANDER, "The ethanolamines and their industrial use," *Rev. prod. chim.*, **33**, 33–37 (1930).
(3) HARVEY, "Triethanolamine," *Am. Dyestuff Reptr.*, **19**, 185–7 (1930).
(4) WILSON, "Triethanolamine emulsions," *J. Ind. Eng. Chem.*, **22**, 143–6 (1930).
(5) JANISTYN, "Use of triethanolamine and its derivatives in cosmetics," *Chimie et Industrie*, **28**, 134 (1932).
(6) DE NAVARRE, "Triethanolamine emulsions," *Am. Perfumer*, **27**, 650–2 (1933).
(7) British Patent 403,118, "The coloration of materials made of or containing cellulose esters or ethers" (1932).
(8) French Patent 781,430, "Fabrication de colorants" (1935).
(9) CLARK, "Analogs of tetryl I. Trinitrophenylnitraminoethyl nitrate (Pentryl)," *J. Ind. Eng. Chem.*, **25**, 1385–90 (1933).
(10) GOLDBERG AND WHITMORE, "Preparation of para-aminobenzoic esters of monoalkylamino alcohols," *J. Am. Chem. Soc.*, **59**, 2280 (1937).
(11) British Patent 482,886, "Local anesthetic bases" (1936).

Seventy-Five Years of Chemistry at Lehigh University[1]

R. D. BILLINGER *Lehigh University, Bethlehem, Pennsylvania*

A DIAMOND jubilee is quite appropriate for a University whose origin was due to the black diamonds of Pennsylvania. Seventy-five years have passed since Asa Packer, who had been a successful entrepreneur in coal and transportation in Carbon County, founded the University which bears the name of the valley in which he lived.

When Lehigh University started in the autumn of 1866 its department of chemistry consisted of but one professor, Dr. Charles Mayer Wetherill. With only a few students majoring in chemistry the laboratory was confined to small quarters in the original campus building, Christmas Hall. In the first class graduated (1869) there was one chemistry student. In 1940 there were 68 majoring in chemistry and chemical engineering. To handle some 300 chemistry majors, plus a like number of students in service courses to other departments, a teaching staff of 21 members is employed.

In the history of the department 975 students have been granted undergraduate degrees. Until 1906 the degree of A.C., Analytical Chemist, was granted. Since then B.S. in Chem., and Ch.E. degrees (more recently B.S. in Ch.E.) have been established. In addition graduate degrees of M.S. and Ph.D. are showing a steady increase. Annually there are now about thirty students taking graduate work, most of whom receive the Master's degree.

THE PILOTS—DEPARTMENTAL HEADS

There have been five departmental heads over the span of years. Dr. C. M. Wetherill (1866–71), Dr. W. H. Chandler (1871–1906), Dr. W. B. Schober (1906–14), and Dr. H. M. Ullmann (1914–38) were followed by the present incumbent, Dr. H. A. Neville (1938–). To these men must be given the major share of credit for growth of the department. Brief outlines of their several careers and contributions follow.

Charles Mayer Wetherill, Ph.D., M.D., was one of the original faculty of five scholars selected to chart the courses of the young technical institution. Wetherill was rich in training and experience, and came from a family well known in the industrial and scientific world. A graduate of the University of Pennsylvania, he had furthered his training in the well-known Philadelphia laboratory of Booth and Boye. His education was completed by a year with Pelouze in Paris, and two years with Liebig in Giessen. Here he received the doctorate in 1848. In the interval before coming to Lehigh he had been successively public analyst, lecturer, traveler, first chemist of the Department of Agriculture, special investigator for President Lincoln on gunpowder production, and chemist for the Smithsonian Institute. His published researches cover papers on medical, agricultural, and mineralogical subjects. His interest in the first field had led the New York Medical College to grant him an honorary M.D. degree. His longest treatise was a book published in 1860 on "The Manufacture of Vinegar." One of his most important pieces of work in Washington was a study and plan for the ventilation of the Capital Building.

The first chemical laboratory consisted of two rooms in the west end of Christmas Hall—the first building on the Lehigh Campus. In 1868 the laboratory was moved to Packer Hall where Wetherill designed an excellent laboratory on the first floor. For his first classes he prepared and printed "A Syllabus of Lectures on Chemical Physics" and two years later "Lecture Notes in Chemistry."

Despite the duties of arranging courses, lectures, and designing laboratories, Wetherill had time for research on the mineral itacolumite (articulite) and his paper was commended by the well-known geologist Dana. Before Wetherill's sudden death in 1871, he had considered a change to the chair of chemistry at the University of Pennsylvania.

One of Penn's greatest alumni, the late Edgar Fahs Smith, Professor of Chemistry and later Provost, wrote an illuminating biography of Dr. Wetherill. This seventy-page tribute[2] establishes Wetherill as one of the outstanding American chemists of his day.

Dr. William Henry Chandler[3] was the second department head to occupy the chair of chemistry from 1871 to 1906. The Chandler influence in American chemistry was long felt, not only through the activities of the Lehigh professor, but also through the work of his illustrious brother, Dr. C. F. Chandler of Columbia. William Chandler received his A.B. and A.M. degrees at Union College, where he studied under his brother. In 1873 he was awarded his Ph.D. from Hamilton College. For three years he was instructor at Columbia, again working with his brother Charles. At intervals prior to this he had done industrial work in the copper works of New Bedford, and in the turpentine and phosphate industries of the South. He was well equipped to carry on the guidance of young chemists in the University in Bethlehem.

[1] Presented before the Division of the History of Chemistry at the 102nd meeting of the A. C. S., Atlantic City, New Jersey, September 10, 1941.

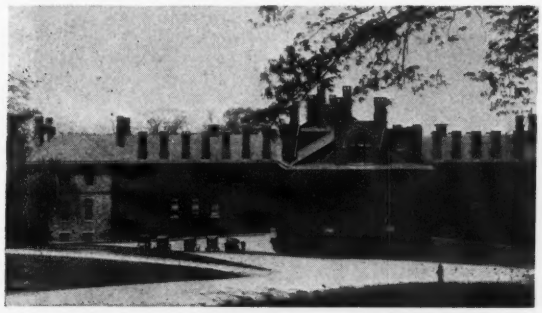
[2] SMITH, "Charles Mayer Wetherill, 1825–1871," J. CHEM. EDUC., **6**, 1076, 1215, 1461, 1668, 1916, 2160 (1929). Contains several portraits.

[3] For a portrait of Dr. Chandler see J. CHEM. EDUC., **16**, 254 (1939).

During this period the Chandlers edited *The American Chemist*, seven volumes of which appeared from 1870–77. This was a monthly journal of theoretical, analytical, and technical chemistry published in New York by W. Baldwin and Company. It was a very important beginning in the literature of American chemistry and no doubt inspired the subsequent publications of the American Chemical Society. The Chandlers also conducted an analytical laboratory in New York City.

During Dr. Chandler's thirty-five years with the University he served as Librarian for most of his incumbency. His interest in books led him to purchase many rare volumes which are now greatly treasured. His energy and intellectual ability were attested by the publication of a three-volume "Encyclopedia and Epitome of Universal Knowledge." This was published in 1878 by P. F. Collier, New York.

The work of which Professor Chandler was most proud was the erection of the chemical laboratory—since named for him. He planned it and supervised its erection with the help of Addison Hutton, Philadelphia architect. The construction occurred between May, 1884, and September, 1885. The main building was 259 by 44 feet, and consisted of two principal stories, a basement, and a smaller third story. A south wing 62 by 42 feet was connected to the main building. Chandler had made a study of important laboratories in this country and abroad and after the experience gained in erecting his own building he published his findings in a book, "The Construction of Chemical Laboratories." This was printed in Washington by the Government Printing Office when Chandler was a U. S. Commissioner to the Paris Exposition in 1889.



SOUTH SIDE OF THE WILLIAM H. CHANDLER CHEMISTRY LABORATORY
Photo made in 1925 showing west wing constructed in 1922

Some of Dr. Chandler's researches are indicated in government publications on "Textile Fabrics, Wearing Apparel and Accessories" and "Products of Mining and Metallurgy." He was especially proud of his Chemical Museum in which he had collected many interesting specimens of natural and industrial production.

Succeeding Dr. Chandler, who died in 1906, came Dr. William B. Schober, a native of Maryland, graduate of Johns Hopkins University, and organic chemist. Schober had done work on diazo compounds and sulfonic acids and translated Gatterman's "Laboratory

WILLIAM BUSH SCHOBER
Department Head 1906–14

Manual of Organic Chemistry"; he faithfully taught at Lehigh from 1892 to 1914. He retired from the department and spent his later years in Florida, succumbing to ill health in 1935.

From 1914 to 1938 the department was under the direction of Dr. Harry Maas Ullmann—aptly described in Bowen's "History of Lehigh" as "able executive and efficient administrator." No detailed account of Dr. Ullmann's career will be repeated here. It was the subject of a biographical sketch in the July 20, 1936, *News Edition* of *Industrial and Engineering Chemistry*—written by one of his former students, Mr. A. E. Buchanan, Director of Research for the Remington Arms Company.

Dr. Ullmann, native of Missouri, came to Lehigh in 1914 from the influence of Ira Remsen at Johns Hopkins and two years study in Munich and Paris. His early work in Bethlehem was in the field of quantitative analysis. Among his published papers are methods of rapid analysis for ash and phosphorus in coal and coke, and a method for the determination of titanium in cement rocks. It was Ullmann (in 1903) who laid out the curriculum in chemical engineering during Dr. Chandler's administration, with the guidance of the University President, Thomas M. Drown. Drown had been Professor of Chemistry at Massachusetts Institute of Technology and his advice was invaluable.

Dr. Ullmann's greatest success was in building up his department and surrounding himself with a congenial staff which combined intellectual activity with a remarkable *esprit de corps*. He labored at great length with students—"the quick and the dead."

Dr. Harvey A. Neville has been head of the department since 1938. A diplomatic Virginian, graduate of Randolph-Macon and Princeton, Dr. Neville had seven years' experience at the University of Illinois before joining the Lehigh staff in 1927. His guiding hand has directed several courses of study, with chief interest and accent in the realm of colloids and catalysis. He is an acknowledged expert and consultant to the plastics industry.

HARRY MAAS ULLMANN, PROFESSOR EMERITUS
Department Head 1914–38

BUILDINGS

As the University grew the chemistry laboratories were moved from Christmas Hall in 1868 to larger quarters in the newly erected Packer Hall. Here Dr. Wetherill had ample space for his lectures, laboratory work, and museum collection. In 1884 Dr. Chandler moved to the present building which he designed and which bears his name. This fireproof, sandstone building has been described briefly under Chandler's work.

Additional extensions have been made to the original building. A three-story extension 60 by 37 feet was added in 1921 to the western end, and an east wing 116 by 52 feet was completed in 1938. The three-story east wing, completely modernized to afford facilities for research, chemical engineering laboratories, and an excellent laboratory for general chemistry, was provided by funds donated by the alumni. The trustees have named the east wing the Harry M. Ullmann Chemistry Laboratory, in recognition of his 25 years of service as head of the chemistry department.

Pictures of the main building show the old-fashioned chimneys which were the source of fume hood ventilation used in Chandler's day. The new annexes now utilize power fans and blowers to remove fumes.

COURSES

An interesting survey of the early courses offered in 1866 is obtained from the first Register of the University. The courses listed for the School of Analytical Chemistry were:

JUNIOR SCHOOLMEN

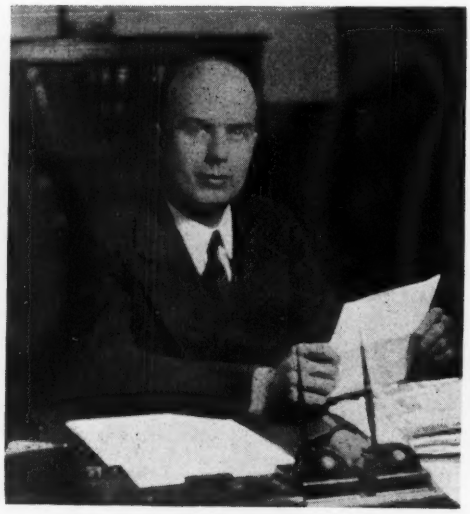
Qualitative Analysis—(Fresenius), English translation. Use of the blowpipe (Plattner). Use of the spectroscope. General Chemistry (Miller's Inorganic). Lectures by the Professor and constant practice in the Laboratory.

Physics—Lectures on Chemical Physics.

SENIOR SCHOOLMEN

Qualitative Analysis—(Liebig), Specific gravity of vapors and gases. Volumetric analysis (Mohr). Quantitative blowpipe analysis (Plattner). Chemistry applied to the Arts (Knapp) in common. Lectures in Chemical Physics. Metallurgical and Technical analysis and assaying (Bodemann's Probirkunst). Dialysis. Bunsen's gas analysis. Chemistry applied to agriculture and the arts; methods of analyzing soils.

With the passing years many new courses of study were offered and older ones dropped, keeping in line with general practice. Today there is a list of some 53 chemistry and chemical engineering courses offered to undergraduates, and 30 more to graduate students. Much more emphasis has been placed in recent years upon advanced courses in physical and organic chemistry, kinetics, thermodynamics, colloids, catalysis, chemical engineering design and practice, with accompanying research problems. However the effort has been made to keep the fundamental courses of general and analytical chemistry of such a nature as to be most helpful to the training of engineers, which has been Lehigh's chief aim throughout the years.



HARVEY ALEXANDER NEVILLE
Department Head 1938–

STUDENT CHEMICAL SOCIETY

"In the first year of Professor Chandler's administration, 1871, The Chemical Society of The Lehigh University was founded and has been active continuously in a highly successful career for seventy years."

This statement by Dr. H. M. Ullmann is but a modest summary of one of the factors chiefly responsible for the *esprit de corps* in the department. It is one of the pioneer student chemical societies in America. Besides fostering the scientific spirit by bringing distinguished scientists to speak at meetings, and in the earlier years by financing trips to distant points for the collection of museum specimens, the Society has served an important social function for students and staff. Its annual Christmas party assembles some three hundred members and guests to a grand banquet. Chief sponsor for this event is Professor A. A. Diefenderfer.

FELLOWSHIPS

Various industrial fellowships have been established to foster research and provide funds for graduate students. These have included researches on silk, leather, drying oils, resins, carbon black, chromium compounds, paint, etc.

Unique among research fellowships is a plan inaugurated in 1927 by the Class of 1930 (freshmen) to donate refunds of laboratory deposits toward the establishment of research fellowships for Lehigh graduates. This fund has grown to well over $20,000 and is a lasting tribute to the spirit of Lehigh students. Recipients of these fellowships have done research in physical chemistry, organic chemistry, and X-ray studies.

PUBLICATIONS

From the very first year of its establishment the department has encouraged faculty publications of texts and contributions to the technical literature. Approximately 330 publications have been produced covering a wide range of subjects. Nationally known texts have been published in the fields of chemical calculations, qualitative analysis, and general chemistry experiments. For years also the English translation (by Professors Schober and Babasinian) of Gatterman's textbook for the organic chemistry laboratory was widely used. Well known have become the researches of Dr. J. S. Long on the drying oils, the work of Dr. E. R. Theis in tanning technology, the vapor pressure studies of hydrates by Dr. W. W. Ewing, and the colloid and plastic researches of Dr. H. A. Neville. Less known, though equally important studies of other staff members have resulted in important contributions to analytical, physical, and organic chemistry, X-ray analysis, chemical engineering, chemical education, and history of chemistry.

GRADUATE WORK

Lehigh University has for many years encouraged a small group of graduate students to pursue work for the Master's degree. In fact the doctorate was established as far back as 1893 when Joseph W. Richards attained it. Dr. Richards' distinguished career as a metallurgist and electrochemist proved that he merited this distinction of being Lehigh's first Ph.D. Another doctorate was granted in 1896 to Dr. H. E. Kiefer. Then for many years only the Master's degree was given until in 1937 the doctorate was re-established. The present number of graduate students total 25–9 studying toward the doctorate and 24 toward the Master's degree. Of this number 25 go forward in chemistry, while 4 are in chemical engineering. This is in contrast to the undergraduate students which number 315, of which 261 are in the curriculum of chemical engineering and 54 in the chemistry curriculum.

GRADUATES

An industrial organization is known by its products. Similarly a University is known by its graduates. As the college president is reported to have said, "We guarantee the product or we will return the student."

Lehigh graduates are to be found in many prominent positions. A roster of these is impossible here, but such a list would include men prominent in the production of steel, coal, oil, paint, linoleum, drugs, arms and ammunition, fertilizers, and many allied chemical fields as well as in academic positions.

ACKNOWLEDGMENT

This paper is but part of a longer report being prepared by the author in connection with the seventy-fifth anniversary of the University. The author is indebted to many alumni and members of the University staff for information. To Professor Emeritus, Dr. H. M. Ullmann, he is indebted for important details of the long period from 1894 to 1938, during which time Dr. Ullmann was actively engaged on the campus.

To another person belongs much credit for inspiring an interest in the early activities of the department. This was Mr. Henry C. Huettig who for 57 years was a member of the department as faithful stockroom keeper and lecture assistant. No Lehigh man since 1878 failed to know Henry. To him books and poems were dedicated in spite of the fact that he often "ruled the roost" with a stern hand. He died on September 2, 1941.

SALT THIS TO TASTE

It seems that an experimentally minded gentleman, after several hours of unsuccessful fishing in the upper reaches of the Powder River, finally came to a point where the stream formed a sharp hairpin bend. Stationing his assistant with a bushel basket on the bank, he walked up the creek to a point where the stream was comparatively narrow and there dumped a quantity of sodium silicate into the water. The results, so the story goes, were exactly as had been anticipated. The fish swam through the silicate which stiffened their tails so that they were unable to make the turn in the stream and they accordingly piled up in the basket until the men had more than enough to satisfy their needs.

—From *Silicate P's & Q's*

Objective Test Items of the Recognition Type That Test Reasoning and Minimize Guessing[1]

THEODORE A. ASHFORD *University of Chicago, Chicago, Illinois*
WILLIAM M. SHANNER *Civil Aeronautics Authority, Washington, D. C.*

OBJECTIONS TO RECOGNITION TESTS

ALTHOUGH examinations of the recognition type have demonstrated their usefulness in that they can be scored reliably and with a relatively small expenditure of time, there remain a number of valid objections to them. One objection is that they test primarily factual information which depends largely upon memory, to the exclusion of testing of reasoning. Another objection is that inasmuch as there is a limited number of alternatives, the student might merely guess the correct answer.

In discussing the first objection we encounter at the outset the unsolved problem of establishing criteria for differentiating between memory and reasoning. It is beyond the scope of this article to establish an adequate set of such criteria. However, it might be pointed out that, if a student exercises memory, he makes a response more or less automatically. Such response is direct and usually requires very little time. On the other hand, if a student exercises reasoning, he goes through a more or less complex train of mental manipulation before he arrives at the final answer. Such response is the result of an integrated reaction on the part of the student. While this distinction is not rigorous, the authors believe that it is such a distinction that most teachers have in mind particularly when they brand true-false items as testing only memory.

If this distinction be accepted as one differentiating between memory and reasoning, it seems that the development of items that test reasoning would be in the direction of requiring the student mentally to manipulate raw data before he formulates the final response. Many types of such items have been developed and used extensively in recent years. One type gives the student a situation with the pertinent data and requires him to select a correct prediction. The following item is given as an example:

1. When a metal X is placed in a solution of hydrochloric acid, it goes into solution with the evolution of hydrogen. When metal Y combines with oxygen, considerably more heat per gram of oxygen is given off than when metal X combines with oxygen.

   A reaction between metal Y and oxide of metal X
   —— will proceed with the evolution of heat.
   —— will proceed with the absorption of heat.
   —— will not proceed.
   —— may or may not take place, depending upon the nature of the oxides.

A further development of this type of test item is made when the student is required not only to make a prediction but also to give the correct reason for making this prediction. Thus the item in the example given above may be followed by this item:

2. The basis for the prediction is:

   —— metal X is more active than metal Y.
   —— metal X is above metal Y in the electromotive series.
   —— more heat is given off in the formation of oxide of metal Y than is required to decompose the oxide of metal X.
   —— less heat is given off in the formation of the oxide of metal Y than is required to decompose the oxide of metal X.
   —— an equilibrium may shift to the right or to the left by the use of appropriate methods.

Paired items of this type have been used in comprehensive examinations at the University of Chicago since 1939. As will be shown later, they are found very effective in discriminating between good and poor students. Moreover, the students have often expressed themselves favorably toward them, a typical remark being "you have to know why before you can answer them."

Further development of this type of test item proceeded from statistical considerations which meet, to a large extent, the objection that recognition test items are subject to guessing. It was recognized at the outset that the responses made by students on recognition items are not subject to a unique interpretation. Thus, if a student answers an item incorrectly, it might be either that he has positive misinformation or that he guessed unsuccessfully. Likewise, if he has answered an item correctly, it might be either that he knows the answer or that he guessed successfully. We might further differentiate between "intelligent" and "blind" guessing. The former is, in a certain sense, knowledge, for the student brings in a good deal of related knowledge and selects the most plausible response after eliminating the others. This type of guessing can be overcome to a certain degree, if desired, by writing decoys (wrong responses) which are apparently more plausible than the correct response. The latter type of guessing is based purely on chance. Inasmuch as there is only a limited number of alternatives, the student might get the correct response by indiscriminately selecting one of the alternatives. Thus in a test of true-false items the student will guess correctly, on the average, 50 per cent of the items.

How serious this element of guessing is depends upon the length of the test, the size of the class, and the information we seek to derive from the test. If, for ex-

[1] Presented before the Division of Chemical Education at the 102nd meeting of the A. C. S., Atlantic City, New Jersey, September 11, 1941.

ample, we are interested in the total score of an individual and the test is fairly long, we can approximate his absolute achievement by using the scoring formula

$$R - \frac{W}{n-1}$$

where R is the number of correct responses, W the number of incorrect responses, and n is the number of alternatives for each item. Similarly, if we are interested in the performance of a class on a particular item, and the class is fairly large, we may use the same formula. However, if the test is short or the class is small, the probable error becomes large and makes any conclusions from the analysis uncertain. The maximum uncertainty is present when we are interested in knowing whether a given individual who has answered a given item correctly did so because he knew the answer or because he guessed successfully.

An obvious method of reducing this element of chance is to increase the number of alternatives. Thus while in a two-response item the student has a 50 per cent chance of guessing successfully, in a five-response item he has only a 20 per cent chance. There are, however, practical limitations to this remedy. Increasing the number of alternatives beyond five does not materially decrease the element of chance. Thus, in a ten-response item, the chance is still 10 per cent. Moreover, it is usually difficult to find many plausible decoys, so that the alternatives become merely space fillers. Even when a large number of plausible alternatives can be written easily, the test becomes unwieldy and wasteful of time.

A NEW METHOD OF SCORING

It occurred to one of us that the chance of guessing can be materially reduced if the pair of items testing a prediction and reason is so scored that a student receives credit only when he answers correctly both the prediction and the reason. In the particular pair of items cited above, the chance for successfully guessing the prediction is $^1/_4$, the chance for successfully guessing the reason is $^1/_5$, but the chance for successfully guessing both at the same time is $^1/_{20}$ or 5 per cent.

It is important to state explicitly the assumptions underlying this procedure. It is assumed that *both prediction and the reason together test a single idea*, and that a student does not really know this idea unless he answers both the prediction and the reason. To what extent this assumption is justifiable depends upon the particular pair of items to which this method is applied. It has been the experience of the authors and their colleagues that test items can be written in which this assumption is justifiable on rational grounds.

This method of scoring need not be restricted to the pairs of items that bear the relation of "prediction" and "reason" but may be extended to any pair of items that test a single idea or elicit an integrated response from the student. The following are examples of items actually used in comprehensive examinations:

The uranium atom has an atomic weight of 238 and an atomic number of 92.

3. The number of protons of which the nucleus of the uranium atom is considered to be built up is:
   —— 54
   —— 92
   —— 146
   —— 238
   —— 330
4. and the number of neutrons is:
   —— 54
   —— 92
   —— 146
   —— 238
   —— 330

An electric iron, when connected to the 110-volt line, draws 5 amperes.

5. The power rating of the iron is:
   —— 5/110
   —— 22
   —— 110
   —— 550
6.
   —— joules
   —— watts
   —— ohms
   —— volts
   —— amperes

In the first pair of items it seems reasonable for the examiner to take the position that the student does not know the *constitution of the nucleus* as a *single* idea if he does not get both the number of protons and the number of neutrons. Similarly in the second pair, it is reasonable to take the position that the student does not really know the answer if he gets only the number but not the electrical units, although it might be argued that, conversely, the student knows "something" if he gets the electrical units but fails to get the number.

Another type of item developed recently is given in part below.

The following observations have been made on four metals X, Y, Z, and W.

I. Metal X dissolves in hydrochloric acid.
II. When metal Y is heated with oxide of metal X, metal X is liberated and the oxide of metal Y is formed with the evolution of a great deal of heat.
III. Metal Z does not dissolve in hydrochloric acid.
IV. Metal Z displaces metal W in a solution of WCl_3.
V. A galvanic cell made of a rod of Z dipping in a solution of the chloride of Z, and a rod of X dipping in a solution of chloride of X, has a voltage of 0.8 volt.

7. Metal X is:
   —— more active than metal Z
   —— about as active as metal Z
   —— less active than metal Z

8. This conclusion is based on statement
   —— I
   —— II
   —— III
   —— IV
   —— V

9. Metal Y is:
   —— above metal W in the electromotive series
   —— below metal W in the electromotive series

10. This conclusion is based on statement
—— I
—— II
—— III
—— IV
—— V

In this type the student is required not only to select the correct prediction but also to trace the reasoning of the prediction back to the data upon which it is based. Strictly speaking the student should be given credit only if he gets the prediction and cites at the same time *all* the data upon which it is based.

Still other items have been developed which pair "cause" and "effect"; a "theoretical statement" and its "experimental basis"; "knowledge of a phenomenon" and its "explanation in terms of principles, generalizations, or theories." The authors would welcome any suggestions of pairing other elements of single integrated responses.

THE STATISTICAL JUSTIFICATION FOR THIS METHOD OF SCORING

Test items of the types described above have been included in several examinations at the University of Chicago given to freshmen and sophomores. These examinations are taken by about 500 students, so that statistical analysis gives fairly reliable results.

Item analysis of these items is particularly illuminating. In this analysis the population is divided into three groups: a "high" group consisting of the upper third of the class as determined by the score on the examination as a whole; the "middle" group consisting of the middle third; and the "low" group consisting of the lowest third. These groups are often designated as "good," "average," and "poor" students, respectively. Each pair of test items is then analyzed to find the percentage of each group that answered correctly the prediction, the reason, and both at the same time.

Analysis of a typical paired item gives the following results:

The particular pair is items 1 and 2 given previously. The analysis was made on random samples of 100 papers for each group. (All figures are given in per cent.)

	High	*Middle*	*Low*
Right prediction and right reason (RR′)	91	70	50
Right prediction (R)	94	73	55
Right reason (R′)	92	81	63
Probably guessing prediction successfully (R − RR′)	3	3	5
Probably guessing reason successfully (R′ − RR′)	1	11	13

More reliable results are obtained by analyzing the entire section containing such items. This section was a part of the six-hour comprehensive examination for the Physical Sciences General Course of June, 1940. The section consisted of 38 paired items, but owing to the fact that a few items had more than one correct response, the number of correct paired responses was 44. The analysis was made on random samples of 100 papers from each group. (All figures are in per cent.)

	High	*Middle*	*Low*
Right predictions and right reasons (RR′)	77.8	59.2	41.6
Right predictions (R)	85.0	69.2	56.2
Right reasons (R′)	83.8	69.1	55.5
Probably guessing predictions successfully (R − RR′)	7.2	10.0	14.6
Probably guessing reasons successfully (R′ − RR′)	6.0	9.9	13.9

Several inferences can be drawn from these data:

1. The knowledge of the high group is more consistent than that of the poor students.

2. The poor students guess more frequently than good students. It appears that poor students make low scores not because they know only a few ideas well but because they have a vague and confused notion of all ideas.

3. Scoring in combinations reduces the score (made on items scored individually) of the poor students by a proportionally greater amount than the score of the good students. This method gives a test of higher reliability in that it increases the dispersion of the scores. Thus, using the Kuder-Richardson formula[2] we obtain a reliability coefficient of 0.62 if the items are scored singly, and 0.74 if the items are scored in combination.

It is interesting that the analysis given above supports the practice of using the scoring formula. For, if the scoring formula[3]

$$R - \frac{W}{3}$$

is used, we obtain as a correction 5.0, 10.3, and 14.6 for the high, middle, and low groups, respectively, for guessing predictions, and 5.4, 10.3, and 14.8 for guessing reasons. These numbers are remarkably close to those obtained by the method above. Conversely, if we assume the validity of the scoring formula, we obtain support that the items test a single idea, or that their correlation is 1.

It might be objected that scoring *any two* items in combination is likely to reduce the score of an individual, and that the fact that the poor students show a greater correction in the analysis above may be explained by the consideration that poor students are more likely to miss either one of the items than good students are. Such an objection is met in the first place on rational grounds by pointing out that if the items are designed to test distinct ideas, there is no justification for assuming that they test a single idea. This consideration is further substantiated empirically

[2] KUDER AND RICHARDSON, "The theory of the estimation of test reliability," *Psychometrika*, 2, No. 3, 151–60 (1937). Formula 21 was used.

[3] The average value of n in the scoring formula is 100/25.4 for the predictions and 100/23.2 for the reasons. Both values are approximately 4, so that $n - 1 = 3$.

by taking items testing distinct ideas, pairing them at random, and scoring them in combination. Five such pairs of five-choice items have been taken, giving upon analysis the following results:

	High	*Middle*	*Low*
Both items, RR′	58.4	28.6	18.6
First item, R	83.0	49.6	40.0
Second item, R′	69.0	54.8	42.8
"Probably guessing first item," R − RR′	24.6	21.0	21.4
"Probably guessing second item," R′ − RR′	10.6	26.2	24.2

The corrections by using the scoring formula

$$R - \frac{W}{4}$$

are 4.2, 12.6, and 15.0, respectively, for the first item and 7.7, 11.3, and 14.3, respectively, for the second item. Thus the analysis confirms what is already known, namely, that these pairs of items are not perfectly intercorrelated, *i. e.*, they do not test a single idea.

USE OF TEST FOR DIAGNOSTIC PURPOSES

The discussion above illustrates the usefulness of this type of items in obtaining a "true" score of an individual by a reduction of guessing. However, obtaining a total score, though important for grading purposes, is only one of several types of information desired in the educational process. This type of test item can be used as a powerful tool for diagnostic purposes in identifying types of error and discovering kinds of student behavior.

Thus in "prediction-reason" items, in which the reasons are statements of general principles, a common type of error is to give the correct principle but make the wrong prediction. If a student makes this kind of error often, he might be identified as one who is familiar with general principles, knows vaguely what principles apply to a given situation, but cannot make the correct application. Another type of error is to give the correct prediction but a reason which contradicts the prediction. This type of student may be identified as one who is not consistent in his thinking. A third type of error is to give an incorrect prediction and give a reason which, though incorrect, is consistent with the prediction chosen. This type of student is probably consistent in his thinking but is probably ignorant of the field tested. A fourth type of error in items requiring a numerical answer and units is one in which the number is given correctly but the units are incorrect. This type of behavior is probably indicative of a person who manipulates figures mechanically and uses the right formula but has no understanding of the significance of his results.

The foregoing examples are given merely as illustrations of the type of information that can be obtained. It is clear that many other kinds of information can be obtained from the various types of paired items.

ADAPTATION TO THE MACHINE-SCORED EXAMINATION

In hand-scored examinations the scoring in combination can be very easily done by merely instructing the reader to give credit only if both items in a pair are correct at the same time. Moreover, this method can easily be adapted to the machine-scored examinations. A special unit is available which permits such a scoring, provided the items are numbered in a prescribed way. It is further believed that a more appropriate unit can be devised to score any two items in combination, provided that demand for such a unit exists.

The authors are indebted to Dr. Herbert Abraham of the Board of Examinations of the University of Chicago for a suggestion which was developed into another method that can be used with the ordinary machine scoring. This we call the matrix method, and is best illustrated by the directions actually included in the examinations.

The following exercises consist of *two parts*. The first part consists of a group of numbered items, corresponding to the *item number* or *row* on the answer sheet. The second part consists of lettered alternatives.

Directions: Read each exercise and select the correct item response *and* the correct *lettered* response or responses. On the answer sheet for the first part, find the correct item number, and *in this row* blacken the lettered space or spaces corresponding to the correct response(s) of the second part.

Item Number

EXAMPLE:

The value of three nickels and two dimes is

61 25 cents
62 30 cents
63 35 cents
64 50 cents

because (A—a dime is worth more than a nickel; B—a nickel is worth 5 cents; C—a quarter is worth 25 cents; D—a dime is worth 10 cents; E—four quarters are worth a dollar).

	A	B	C	D	E
61	⁞⁞	⁞⁞	⁞⁞	⁞⁞	⁞⁞
62	⁞⁞	⁞⁞	⁞⁞	⁞⁞	⁞⁞
63	⁞⁞	▮▮	⁞⁞	▮▮	⁞⁞
64	⁞⁞	⁞⁞	⁞⁞	⁞⁞	⁞⁞

In this EXAMPLE we select the item numbered 63, which is the correct answer for the first part, and in row 63 on the answer sheet we blacken answer spaces B and D which are the correct lettered responses for the second part.

It is observed that by this method only a few (often only one) of the cells in the matrix are correct answers.

The students find no difficulty in answering a test in this form. When the test was introduced, an actual study was made by having with the same examination a number of paired items to be answered individually as multiple response items, and on the next page the same items set up in the matrix form. When the paired items, answered individually, were hand-scored in combination, no significant differences were found from those which were answered in the matrix form and scored by the scoring machine.

The authors are indebted to Miss Jane M. Allison and Benjamin Bloom, both of the Board of Examinations, for assistance in collecting the statistical data.

Ten Questions That Students of Chemistry Will Be Asking—and Their Answers

1. *Why should I not go into active military service as soon as possible, when so many of my friends are doing so?*

Great as the need is for more men in the army, navy, and air force, there is an even greater need—a positive shortage—of technically trained men to fill "officer" positions in the great "production army." The training for these positions is longer and more exacting than that required for military posts. Every candidate for such a position must be conserved.

2. *Will I not be able to make use of my chemical training in the army, navy, or air force?*

Probably not. While your technical training might make you a better soldier there is little real work for a chemist or chemical engineer in the army, navy, or air force. The Chemical Warfare Service is largely a *tactical* branch; it has less part in the actual production of war materials than it had in the last war.

3. *If I wait for my draft number to be called what assurance have I that I will be allowed to complete my training or make use of it afterward?*

While the organization and machinery may not be 100 per cent perfect, it is certainly the *intention* of the Selective Service System to draft into the armed forces only those men whose services are not being put to better use elsewhere. The OPM has made it clear that there is a critical need in the nation's industries for chemists and chemical engineers. Local draft boards have been instructed by the Selective Service System to give especially careful consideration to requests for deferment of trained personnel in the "necessary industries" and students in training for such work. Appeal boards have in many cases granted deferment when it has been denied by the local board.

4. *Will I be automatically deferred by my draft board when it is known that I am a chemist or chemical engineer, or in training to be one?*

No. According to the law there can be no automatic deferment of any class, group, or profession. Every case must be considered individually. You must ask for deferment yourself, the request must be supported by your school or employer on the proper forms, and if it is denied you should then appeal to the state board. Among the agencies which will be glad to aid you if you encounter difficulty are: Secretary of the American Chemical Society, 1155 Sixteenth Street, N. W., Washington, D. C., and the National Roster of Scientific and Specialized Personnel, Washington, D. C.

5. *If I ask for deferment will I not be considered a "slacker"?*

No. The draft system is *selective* and occupational selection is an indispensable part of it. If you are convinced that you are best fitted to serve in a technical capacity in production, persevere, no matter what the unenlightened opinions of others may be. This is not a slacker's escape. If you do not have the ability to become a competent chemist or chemical engineer your instructors will not recommend your deferment and you had better forget all about it.

6. *Why cannot men outside draft age, or those unfitted for military service, fill all the necessary technical positions in the "production army"?*

There are not nearly enough. The industrial expansion planned for 1942 will require many more technically trained men, especially chemists and chemical engineers, than are likely to be available in the whole country. Furthermore, we are planning for a long war and a continual supply of new chemists will be necessary year after year if there is not to be a "gap" in the ranks.

7. *Is it right that we should stay in school for two or three years, preparing ourselves for production services so far ahead in the future, when there is crying need for action now?*

We must look forward to our needs two, three, perhaps eight years from now. If we do not assure ourselves of a continuous supply of chemists and chemical engineers we will most certainly come to regret it. It is insurance for the "production and supply" side of our war effort. The training of a chemist or engineer for production requires much more time than does that of an artillery officer or airplane pilot—important as the latter two may be.

8. *Should I plan to continue for a graduate degree or should I get into the "production army" as soon as possible?*

While the question of graduate study will be a more difficult one for the duration of the war than it has been hitherto, it must be considered in much the same way. You will be a more valuable man the more highly trained you are. Even now there are war research projects going on which are hampered by lack of properly qualified men. There is a constantly increasing demand for holders of advanced degrees for this kind of work. The individual student must appraise himself as carefully as he can and seek the advice of his superiors, in the effort to decide whether he is promising enough to warrant the extra time for his training. More steel is used up in making a sixteen-inch gun than a five-, but the result in performance is worth the difference. We need both.

9. *How do I know that my services will be really used, after I have completed my training?*

In view of the present shortage of chemists and chemical engineers to fill jobs now open, it seems unlikely that while the war lasts there will be any difficulty in finding a place for every well-trained one we can supply. During the early days of the draft a few employers thought it their patriotic duty *not* to recommend the deferment of any of their employees. They were later convinced, largely by Selective Service officials, that this was a mistaken conception of patriotism.

10. *Will I find myself in a "blind alley" after the war is over if I train myself to enter a war industry as a chemist?*

Even a blind alley has one way out. Many of our boys will be in worse places when this war is over. For the moment, we must consider only the way in which you can best serve your country. Nevertheless, even with the inevitable deflation resulting from the collapse of war industries, chemists and chemical engineers will be needed to convert industry to a peace-time basis. Technical training and experience will be peace-time assets.

High-School Chemistry

Modern Uses of Oxygen[1]

G. O. CARTER and H. F. REINHARD

The Linde Air Products Company, New York City

OXYGEN is our most abundant element. It forms 21 per cent of the atmosphere, 89 per cent of the water, and about 50 per cent of the earth's crust. Without oxygen, all life would cease, all fires would go out. Just as surely as oxygen is essential in supporting respiration and combustion, so, too, is its use indispensable in many modern industrial processes. For oxygen has probably contributed as much to our industrial development as have such things as electricity, steam, coal, or oil.

Before discussing present-day uses of oxygen, however, it might be well to review, briefly, the commercial development, production, and distribution of this vital element.

THE COMMERCIAL DEVELOPMENT OF OXYGEN

Although oxygen has been a factor in industry for less than 40 years, there has been interest in this colorless, odorless, tasteless gas for several hundred years. Its presence as an active element in the air was suspected as long ago as 1500 A.D., but it remained for Antoine Lavoisier, a French chemist, in the year 1777 to name oxygen and actually describe its properties.

In spite of the early advances made by Lavoisier, actual development of the industrial application of oxygen for the next hundred years was extremely slow. Then, at the turn of the twentieth century, two factors greatly speeded progress. One was a method for economically producing oxygen of high purity from the air, while the other was the almost simultaneous development of a method for producing calcium carbide on a commercial scale.

HOW OXYGEN IS PRODUCED

Probably 95 per cent of the huge volume of oxygen used today is obtained from the air by a process which was developed by Dr. Carl von Linde in Germany in 1895 and 1902. This method is based upon the liquefaction of air and its fractional distillation. Technically, the process is complicated, with special machinery and expert supervision necessary. This process requires one of the lowest temperatures used industrially —more than 300°F. below zero (−184.4°C.). Since ordinary refrigerating methods are not adequate for producing such low temperatures, use is made of certain physical properties of the gases to effect liquefaction.

The liquid air thus obtained is an intensely cold mixture of liquid oxygen and liquid nitrogen. Oxygen is then separated by rectification, wherein advantage is taken of the fact that the nitrogen is in a gaseous state at a temperature at which oxygen is liquid. The rectification apparatus delivers high-purity oxygen for direct use or for compression into steel cylinders. Most oxygen produced for industrial purposes is also suitable for human consumption, as it is purer than 99 per cent, which is specified for medical purposes.

THE DISTRIBUTION OF OXYGEN

Oxygen is usually distributed in high-strength steel cylinders. The two sizes of cylinders commonly used measure 51 inches in height by $9^1/_8$ inches in diameter, and 43 inches in height by $7^1/_4$ inches in diameter. These sizes are generally charged with the oxygen at a pressure of 2000 pounds per square inch at 70°F. The large cylinders have a capacity of 220 cubic feet of oxygen, the smaller ones, 110 cubic feet, measured at atmospheric pressure and 70°F. Each cylinder is equipped with a valve, specially designed for high-pressure operation. Other sizes of cylinders and other pressures are permitted if within Interstate Commerce Commission specifications for the manufacture of cylinders.

In steel mills and in other plants using large volumes of oxygen, it is often shipped in liquid form in special trucks and tank cars. At the mill, the liquid oxygen is stored in huge, vacuum-type containers at extremely low temperatures. Here the liquid oxygen is made to evaporate into the gaseous form, as required, and is conveyed to points of use about the plant through pipe lines. Liquid oxygen has a temperature of approximately 318°F. below zero (−194.4°C.) and one cubic foot of liquid vaporizes into 866 cubic feet of gaseous oxygen.

THE OXY-ACETYLENE FLAME

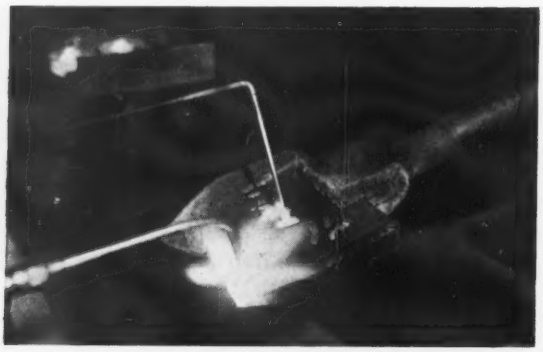
In 1892, Major James Turner Morehead, at Spray, North Carolina, demonstrated for the first time the feasibility of using the high temperatures of the electric furnace for producing calcium carbide on a commercial scale. Calcium carbide treated with water produces acetylene, a gas which burns in air with a brilliant white light.

When the two gases oxygen and acetylene are mixed in proper proportions and burned, their combustion produces the hottest flame known—more than 5400°F. This flame is so intensely hot that it will quickly melt all commercial metals, and it is this flame which for the

[1] Presented before the Division of Chemical Education at the ninety-ninth meeting of the A. C. S., Cincinnati, Ohio, April 9, 1940.

past 40 years has formed the basis of the oxy-acetylene process for welding and cutting metals.

Today acetylene, just like oxygen, is available in all parts of the country in portable steel cylinders. Also,

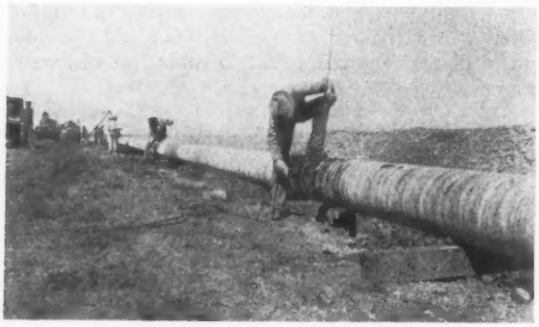


OIL-WELL DRILLING TOOLS LAST MUCH LONGER WHEN PROTECTED WITH A WELDED-ON LAYER OF EXTREMELY HARD, ABRASION-RESISTANT ALLOY

many plants generate their own acetylene from calcium carbide. Calcium carbide, which resembles crushed granite in appearance, is shipped to users of acetylene generators usually in 100-lb. sheet-steel drums.

OXY-ACETYLENE WELDING

In joining metal parts by oxy-acetylene welding, the oxy-acetylene flame is applied to the abutting edges of two pieces of metal which are to be joined; because of the intensely concentrated heat, these edges quickly melt and mix together. Usually the edges are beveled so that they form a vee which must be filled in. Therefore molten metal from a welding rod is added to the veed section. The flame is produced by an oxy-acetylene welding blowpipe which is designed so that the oxygen and acetylene are thoroughly mixed in the correct proportions.



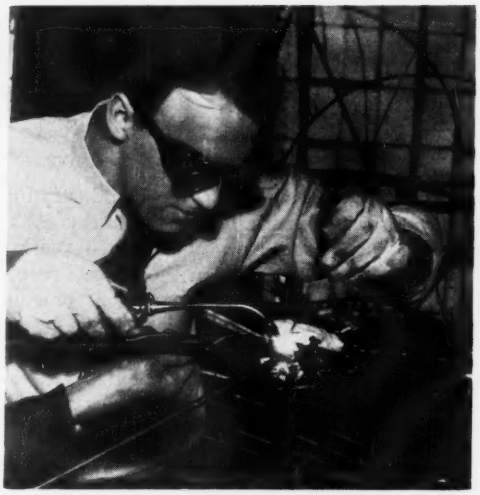
THOUSANDS OF MILES OF PIPE LINES CARRYING OIL AND GAS AT HIGH PRESSURE ARE STRONG AND LEAKPROOF BECAUSE THEY ARE OXY-ACETYLENE WELDED

One of the great advantages of the oxy-acetylene process is that all commercial metals can be welded—from tin with a melting point of 455°F. to platinum with a melting point of about 3200°F. Between these limits are the more common metals which are oxy-acetylene welded, such as aluminum, bronze, brass, copper, wrought iron, cast iron, steel, and alloy steels.

THE REPAIR OF DAMAGED PARTS

The field of oxy-acetylene welding has grown by such leaps and bounds that today there is hardly an industry which does not use the process. Broadly speaking, applications can be divided into two divisions—repair and production.

The repair field is perhaps the better known, for practically every garage in the country uses the oxy-acetylene process for repairing ripped and torn fenders, broken bumpers, damaged grilles, and a hundred and one other automotive parts. Familiar household articles such as



TUBULAR FRAMEWORK OF AIRPLANES, MADE OF CHROMIUM-MOLYBDENUM STEEL, IS JOINED PERMANENTLY BY OXY-ACETYLENE WELDING

lawn mower wheels, furnace grate bars, and stove parts which become broken are quickly restored to as good as new by welding.

In industry, there is not a factory, mill, or mine which does not use the process in many different ways for repairing the multitude of fractures of plant equipment—from tiny loom parts used by the textile industry to huge iron castings, such as rock crushers weighing many tons. In keeping this machinery and equipment operating continuously and efficiently, oxy-acetylene welding plays an indispensable part.

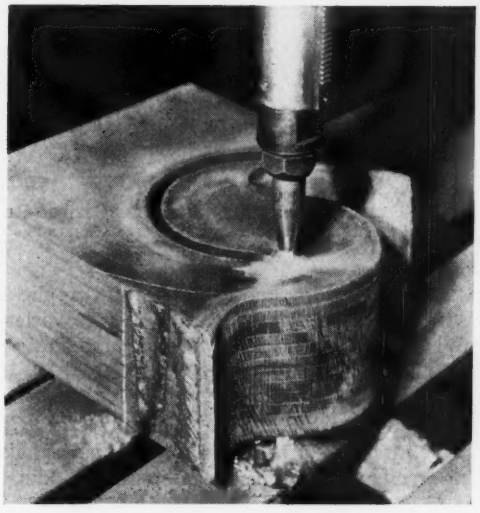
A process allied to welding is known as "hard-facing." Extremely hard, wear-resistant alloys are applied to the surfaces of metal parts which normally wear rapidly, thus increasing the life of the parts many times. Oil-well drilling tools, plowshares, automotive valve seats, and thousands of similar parts are thus protected against wear and abrasion.

PRODUCTION USES OF WELDING

Oxy-acetylene welding is also widely used in the production of metal parts of every description. Minute filaments for radio tubes are welded together, and these production welding operations continue all the way up to such things as locomotive frames and overland pipe lines carrying oil and gas for thousands of miles and more.

Certain industries could not have developed to their present stage without welding. This is notably true in the manufacture of airplanes, streamlined trains, automobiles, and modern refrigerators and air-conditioning units. Metal furniture, barrels, storage tanks, even cooking utensils, are all made stronger and lighter by oxy-acetylene welding.

One of the most recent uses of the oxy-acetylene flame is for welding together the ends of railroad rails. Many miles of jointless track have already been laid,



IN OXY-ACETYLENE CUTTING, A STREAM OF OXYGEN OXIDIZES THE STEEL, PRODUCING A NARROW KERF. HERE TWELVE PLATES ARE BEING CUT AT ONE TIME

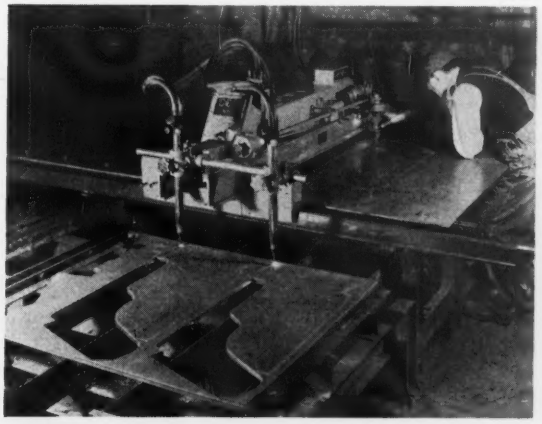
and the future may well see the widespread adoption of this method for eliminating joints.

OXY-ACETYLENE CUTTING

By far the greatest amount of oxygen is used in cutting iron and steel—one of the most spectacular applications of oxygen in industry.

In cutting with oxygen and acetylene, both the oxy-acetylene heating flame and the jet of cutting oxygen are produced and controlled by means of a cutting blowpipe. The oxy-acetylene flame is used to heat the metal at the point where the cut is to begin, to a temperature at which it will burn in the presence of oxygen. Then the separate jet of oxygen is turned on, and the cutting blowpipe moved along the line of cut desired. As cutting progresses the cut produces a relatively narrow slot or "kerf."

This simple process has literally revolutionized the metal-working industries. Iron and steel parts of any commercial thickness, and almost regardless of the



STEEL PLATE FOR HEAVY MACHINE PARTS IS QUICKLY CUT TO ANY DESIRED SHAPE BY MEANS OF OXY-ACETYLENE CUTTING MACHINES

composition of the material, can be rapidly and accurately shaped and severed. Cuts of any contour can be made as easily as cuts that follow straight lines. In addition to the hand-operated cutting blowpipe, electrically driven machines, both large and small, have been developed to move the blowpipe in various cutting and shaping operations.

INDUSTRIAL APPLICATIONS OF CUTTING

With oxy-acetylene cutting, steel beams and columns for building construction can be shaped at will. Parts for heavy steel mill equipment, railroad locomotives, and machinery of all kinds can be produced from great slabs or billets of steel quickly, accurately, and at a minimum of cost.

Steel foundries use the cutting blowpipe for removing risers from castings; forge shops, for cutting billets;

SURFACE DEFECTS ARE QUICKLY REMOVED FROM STEEL BILLETS, DURING ROLLING, BY SPECTACULAR OXY-ACETYLENE CONDITIONING MACHINES

iron works, for shaping structural steel; tank and plate shops, for a hundred and one uses.

Thousands of tons of scrap iron and steel are economically cut to sizes convenient for use in remaking

into new steel. Practically every garage and welding shop has a cutting attachment for its welding blowpipe. This attachment is used for innumerable jobs of repair and maintenance on automobiles, farm implements, and metal equipment for factory and home.

STEEL CONDITIONING

One of the most recent applications of the oxy-acetylene process is for removing surface defects from steel. This is tremendously important in steel mills where the billets and slabs, before they are rolled into sheets and other shapes, must be free from surface cracks and imperfections which might be rolled into the final product. It is essential that these flaws be removed.

This was formerly done with chipping hammers or by grinding after the billets had cooled. Now surface defects are removed with special oxy-acetylene blowpipes which are operated by hand on cold steel and by machine when the billet is red-hot. The machine operation makes it possible to "desurface" steel without interrupting continuous rolling processes. In this way, a larger yield of cleaner and better steel is made possible at lower cost.

FLAME-TREATING APPLICATIONS

Among other recent developments are the so-called "flame-treating" processes whereby iron and steel parts can be hardened, softened, or strengthened by means of the oxy-acetylene flame.

Either an entire piece of metal or only a specified portion of it may be locally heated so that desirable properties of hardness for wear resistance, or softness for workability, may be obtained as required. Rail

THE TEETH OF THIS GEAR ARE GIVEN A HARD, WEAR-RESISTANT SURFACE BY MEANS OF FLAME-HARDENING

ends are hardened by heating before being laid in the railroad beds so that they will last longer under the continuous batter of wheels from passing trains. All types of gears, shafts, rolls, and other parts which must withstand wear can be given surface hardness by means of the oxy-acetylene flame.

Stress relieving, whereby internal stresses in steel are

SPECIAL OXY-ACETYLENE BLOWPIPES ARE USED TO REMOVE THE SURFACE SCALE FROM STEEL CASTINGS

relieved by heating, is another important application. Also, the flame is used for heating a wide variety of metals in hundreds of bending, forming, and straightening operations.

MISCELLANEOUS USES OF THE FLAME

The intense heat of the oxy-acetylene flame makes it useful for many operations in addition to welding and cutting.

Scale is quickly removed from steel billets and castings by "washing" the surface with the flame. Similarly, structural steel is prepared for painting by applying the flame to the surface. This operation, known as "flame-cleaning," removes loose scale and moisture, resulting in a cleaner base and a longer-lasting paint job.

During manufacture, thousands of glass bottles daily undergo a "fire-finishing" treatment. An oxy-acetylene flame directed against the top of the bottle for approximately a second slightly fuses the glass, thus removing molding irregularities.

The flame is also used for charring the surface of wood so as to obtain certain decorative or antique effects. A special blowpipe drills holes in rock and concrete at remarkable speeds.

Oxygen alone, without acetylene, is used for burning out carbon from the combustion chambers of automobile engines; while the intense cold of liquid oxygen is used industrially for making shrink-fits in machine parts.

MEDICAL USES OF OXYGEN

Although by far the greatest volume of oxygen—amounting to several billion cubic feet a year—is used for industrial purposes, an ever increasing amount of oxygen is being used in the treatment of certain diseases. The variety of diseases and ailments in which oxygen treatments have proved beneficial is wide, ranging from pneumonia and heart disease to far less serious but yet troublesome conditions in which oxygen may be lacking.

In recent years oxygen, administered early, continuously, and in adequate concentrations, has been one of the most important factors in the treatment of pneumonia and has been responsible for saving many lives. Even with the recent development of serums and sulfapyridine, oxygen continues to be of real value in the successful treatment of pneumonia. With these great tools of medicine, surprising reductions in the death rate due to this disease have already been made and further reductions are expected.

The effectiveness of continuous inhalation of oxygen in various types of heart disease has been established. In many cases oxygen brings great relief to overburdened heart muscles, thereby reducing restlessness and shortness of breath, and hastening the patient's recovery.

The use of oxygen is also of vital importance following many operations. In such instances when the body is weakened by the effects of anesthetics and by the operation itself, oxygen has been found to relieve rapid pulse, shortness of breath, inadequate blood circulation, shock, depressed respiration, and other postoperative symptoms. In addition, oxygen is frequently used in resuscitation, in certain forms of poisoning, and to relieve certain forms of recurrent headaches.

The relief of oxygen-want at high altitudes is an application that has received considerable notice recently through the decision of many commercial airlines to install oxygen-administration equipment in their airplanes. While breathing oxygen, aircraft pilots can operate efficiently at altitudes that would be impractical without it.

OXYGEN HAS BEEN ONE OF THE MOST IMPORTANT FACTORS IN RECENT YEARS IN THE TREATMENT OF PNEUMONIA AND OTHER DISEASES

Truly it may be said that oxygen is man's best friend—for both in industry and for our human welfare, it is equally indispensable.

LETTERS

Savings in Semimicro Methods for the Beginning Student

To the Editor:

In the September, 1941, issue of this JOURNAL appeared an article[1] on the use of semimicro procedures in the first-year college chemistry course, which originated from the Mars Hill College Chemistry Laboratory.

Since this article was written it has been possible to calculate some savings in this field over the old macro method. Due to interest shown in the September article we would like to give below our figures, together with some explanation.

1. Cost of desk apparatus—semimicro, \$6.19 per student. Cost of desk apparatus—macro, \$9.03 per student. A saving of \$2.84 per student or a 32 per cent saving. In a class of 200 students this amounts to a saving of \$568.00.
2. A 66.77 per cent saving in solid reagents in semimicro over macro methods.
3. A 22.93 per cent saving in liquids and solutions in semimicro over macro methods.
4. This is a total saving of 42.09 per cent on all chemicals used in changing from macro to semimicro methods.

In the compilation of the above figures we used a macro laboratory manual, considered one of the best in the field, that we had used in previous years, along with the semimicro manual that we developed in our own department. As was pointed out previously[1] the experiments for the beginning student are not radically different and so there would be no savings due to complete revision of fundamental laboratory training. The only difference is in the size of the equipment and the quantities of the reagents used.

The above are the tangible savings. Perhaps just as important are savings of an intangible nature. Some of these are listed as follows:

[1] WOOD AND WALKER, "Semimicro chemistry for the beginning student," J. CHEM. EDUC., 18, 427 (Sept., 1941).

1. Savings due to less waste of chemicals. In any laboratory course there will be waste of chemicals, that is, a student will use more material than is necessary according to the directions in the manual. We have found that the student using small equipment tends to use the amount called for much more readily than in the macro method. The reason is obvious to those who have tried it. A large quantity of material just does not seem to look right in small equipment.
2. Savings in time. Time in the laboratory is an important item, especially for the beginning student. In the semimicro method the same type of experiment can be performed in a much shorter period, meaning that the student can complete more experiments and thereby receive more training.
3. A saving of working space, thereby allowing more students in the laboratory per section.
4. A saving of cabinet space, thereby allowing a school to put more student cabinets in a laboratory.

H. RAWORTH WALKER, JR.

MARS HILL COLLEGE
MARS HILL, NORTH CAROLINA

Out of the Editor's Basket

A DESCRIPTION of a holder for melting-point tubes has been sent us by S. W. Lee, of the Wallace Laboratories, New Brunswick, New Jersey. It consists of an ordinary metal pencil clasp which is adjusted to fit tightly on a thermometer stem. A small notch is cut with a triangular file on the inside of the ball end, to hold the capillary tube against the thermometer, the size of the notch and the tension of the spring being adjusted so as not to crush the tube. If an open flask is used for the bath, and the tubes are of uniform length, they may be changed without moving the thermometer.

● Earl K. Dore, of Chicago Teachers' College, suggests a slight change in the conventional demonstration setup for electrical conductivity consisting of electrodes in series with a lamp. A pair of 8-mm. arc lamp carbons, inserted through a two-holed stopper, make convenient electrodes, connection being made with battery clamps.

● We recently noted the results of the National Teacher Examinations, given last March. This was the second year they have been given, under the auspices of the American Council on Education, in the effort to provide a comparable and objective measure of some of the abilities and cultural achievements of prospective teachers. The test items cover intellectual and cultural backgrounds. We were struck by only two points in the summary of results: (a) Candidates with extended teaching experience did *slightly* better than candidates with lesser amounts of experience. (b) Candidates holding higher degrees showed *slight* advantages on the tests over candidates with less training. (The italics are ours.)

● In a paper entitled "Chemistry—Race—Nationality," given by Harrison Hale, of the University of Arkansas, at the Atlantic City Meeting of the Division, we were reminded that during World War I several foreign members of the American Chemical Society were expelled because of their nationality. Later, this hasty action was regretted, but in at least one case—that of Emil Fischer—it was impossible to undo the damage. The turn of events may soon lead us to the same temptation. Let us hope that the community of Science will prove stronger than political differences—even as strong as those which now separate us.

● We learn that world nickel production and consumption in 1941 were at an all-time high. The sharp increase in demand arising from the joint British, Canadian, and United States war effort required nickel production far beyond anything experienced in the past. The United States consumed over two-thirds of the world's nickel output in 1941, as contrasted with an average annual consumption of about one-third during recent years. It is estimated that steel mills in this country are now consuming approximately 70 per cent of the refined nickel imported. Of the remaining 30 per cent, foundries are taking 7.3, heat-resisting and electrical resistance alloys 4.6, electroplaters 2.5, and the balance is required for rolled nickel and high nickel alloys, etc.

● The application of a little simplified research technic can often prick the bubbles of superstition and pseudo-science. Dr. Paul Farnsworth, of Stanford University, was skeptical of the claims of astrologists that persons born under the seventh sign of the zodiac have musical ability. So he simply looked up the birth dates of some 1500 musicians and found that actually fewer musicians were born under the seventh sign than any other except one. The astrologists would have done better to pick one at random—or perhaps they did!

● We understand that the health authorities are anxious for chemists to pick a new name[1] for the pellagra-preventing vitamin. "Nicotinic acid" is not a nice thing to have on food labels because of its suggested identity with nicotine.

● Pursuing the nicotine question further, we would like to express our sympathy for the "gloat" that appears among the editorials of *Food Materials and Equipment.* It seems that the recent advertising campaign

[1] Since this was written the term "niacin" has been proposed.

which had as its theme song the well-known refrain, "Reach for a cigarette instead of a sweet," did untold damage to certain branches of the food industry. In fact, the campaign is labeled as "contemptible industrial sabotage." Of course, that depends upon the point of view, but anyway, not a few firms went out of business. Now it seems that the tables are to be turned. The government will shortly issue suggestions to planters on how to cut down the growing of tobacco, stressing the fact that its cultivation is displacing needed food. The tobacco habit is also being given a hard sock by ex-heavyweight champion Gene Tunney, now Director of the Navy's Physical Fitness Program, who blames it for a good many things. Maybe these boys in World War No. 2 will not be deluged with cigarettes, as we were in 1918. At any rate, the food industry is somewhat exultant and hopes it can pick off an eye for an eye, instead of turning a cheek.

● The part that the American food industry will play in the present war bids fair to be an important one. It has not only its own population to feed now, but also large numbers of our allies who will be dependent upon American food, for the duration. Food manufacturers, chemists, and others are now mightily concerned with the problems of new methods for producing not only more, but better food. And when peace finally comes many countries will probably look to us for the food which will give them the hope for reconstruction.

● And while still on the subject of food we would like to quote the following from *Food Materials and Equipment*, December 20, 1941:

"A number of factors have combined to create temporary bottlenecks in the rapidly mushrooming vitamin industries. Among these are the curtailment of European sources of supply, the enormous consumption of the pharmaceutical industry, government purchases for lease-lend shipments, and the additional requirements for fortification of enriched bread and margarine.

"Greatest bottleneck is in B_2 or riboflavin, where supplies are so tight that federal regulations for inclusion of this vitamin in enriched bread have had to be postponed until July 1. Some easing of the situation is expected in about two months, but fully adequate supplies for food enrichment are not expected until next spring, when new plants and expanded facilities for its production will be in operation.

"B_1 is also in limited supply, but conditions are already improving somewhat, and ample supplies are expected by spring at the latest.

"The nicotinic acid situation is slightly better, though production has been somewhat hampered by government restrictions on use of potassium permanganate except by munitions industries. Other methods of manufacture are being experimented with, and adequate supplies are expected within 60–90 days.

"Supplies of vitamins A and D have been affected by the blackout of imports. Only source of the natural vitamin A is fish liver oils. Removal of Norway as a source of cod liver oil has reduced supplies, and fortification of oleomargarine with vitamin A has increased demands. Some fish liver oil has also been going to Britain in lend-lease shipments. Since fish livers are a by-product of the fish industry, production cannot be increased without a corresponding increase in demand for the fish itself. Only exception to this rule are sharks caught off the west coast, and supplies of these seem limited, too.

"Chief reliance must, therefore, be placed on the pro-vitamin carotene, found in vegetables and dairy products.

"Vitamin D has been derived chiefly from Japanese tuna. However, the vegetable source of vitamin D_2, activated ergosterol, is a good substitute for human consumption, and supplies of this vitamin are plentiful thus far."

● While the following abstracts have been withheld from publication for some time, we feel that they are still pertinent.

A challenge to the liberal arts college. S. HOOK. *J. Higher Educ.*, **10**, 14–23 (Jan., 1939).—Sidney Hook, Chairman, Department of Philosophy, Washington Square College, New York University, piles up his arguments to show that the demand of the present social order upon the liberal arts college is appropriate educational experience to develop intelligent members of society, capable by virtue of their command of relevant knowledge and the methods of scientific inquiry, of making their own decisions.

He says, "The proposed reorganization of the curriculum of the liberal arts college revolves around three fundamental principles: first, making the student aware of the major social problems of the world in which he lives and is going to live, and providing the relevant knowledge from any field necessary to understanding them; second, critically orienting the student to the philosophies of life, society, and history in behalf of which such knowledge is used; and third, emphasis upon method in evaluating both facts and values."

"Ideals and philosophies of life are not parts of the world of nature, but it is a pernicious illusion to imagine that they cannot be studied scientifically. Their historical origins, their concatenation of doctrine, their controlling assumptions, their means, methods, and consequences in practice can and should be investigated in a scientific spirit." A. T. B.

Intelligence is not enough. W. H. COWLEY. *J. Higher Educ.*, **9**, 469–77 (Dec., 1938).—The rise of German universities to world leadership during the nineteenth century resulted from their cutting loose in the middle of the eighteenth century from Aristotelianism and classical humanism and starting on the road of science a century before most English and French professors were seriously aware of the existence of the scientific method.

Aspiring young scholars and scientists flocked to German universities, and the majority of the Americans who studied in Germany returned to professorships in American colleges. They established learned journals and judged themselves and their colleagues upon the number of erudite articles which they produced. They taught their subjects as ends in themselves, rather than as means for the educating of college students. They abandoned the holoistic conception of the historic American college.

Mr. Cowley takes a stand on the side of the traditional British-American philosophy of education; namely, that the purpose of the college is the training of the whole student, not of his mind alone.

The holoistically educated individual is not only socially well poised, ethically cultivated, and emotionally mature, but he is also intellectually informed, and alert and disciplined. The word "whole" means what it says—wholeness of mind and body and spirit. The extreme which produces the country-club college is just as reprehensible as the extreme which produces the intellectual treadmill.

The way out seems to Mr. Cowley to be to return to the ideals of the early American college; strengthen these ideals with biological, psychological, and sociological insights that have been developed in recent decades; build up faculties made up of men who are not only thorough scholars in their specialties, but also broadly educated gentlemen and highly skilled teachers.

A. T. B.

Employers' views on education. J. L. BRAY. *Chem. & Met. Eng.*, **46**, 80–1 (Feb., 1939).—One hundred twelve executives of over fifty large chemical and metallurgical companies were consulted regarding (1) the wisdom of expanding present facilities for chemical engineering education, (2) the outlet for graduates in this line, and (3) the curriculum which, in their minds, would best fit graduates for a successful career in industry.

Executives were unanimous in believing the four-year undergraduates' course should confine itself to the fundamentals of mathematics, physics, chemistry, English, and engineering. A

fundamental weakness of the present-day graduate is the use of the English language. He is unable to express himself in the form of a concise, logical, and even correctly spelled report, and such a deficiency constitutes a serious hazard in his subsequent career.

Since most of the ills besetting us in this day and age are economic rather than technological, men must be able to handle men as well as money and materials.

The proper place for specialization is in the graduate years, but only thirty per cent should go on to the Master's degree and not over ten per cent to the Doctor's degree.

The university should not attempt to turn out graduates capable of operating special equipment, for that skill can be acquired sooner and at less expense in industry. The use of a still or filter press, for example, should only be taught to illustrate certain fundamental laws.

It is felt that there will be an increased demand for graduates of the requisite interest and ability, but many students are entering this field who are not temperamentally or mentally suited to it. J. W. H.

Pope Pius XI and his scientific interests. T. GREENWOOD. *Nature*, **143**, 274 (Feb. 18, 1939).—"The crowning example of the Pope's interest in pure science was the reconstitution in 1936 of the Pontifical Academy of Sciences, which is now housed in the Casina Pio IV in the Vatican gardens, through the generosity of Pius XI himself. The Academy, which was known in the past as the Pontificia Accademia dei Nuovi Lincei, now consists of seventy members chosen from among the most distinguished men of science, irrespective of nationality and of religious profession. . . At the inaugural meeting of the Pontifical Academy last year, Pope Pius XI paid a personal tribute to the benefits conferred on mankind by the labours of Marconi. . . and of Hertz, to whose widow now living in exile at Cambridge His Holiness made a personal gift of £250. . ." M. E. W.

RECENT BOOKS

THE GLASS ELECTRODE. METHODS, APPLICATIONS, AND THEORY. *Malcolm Dole*, Associate Professor of Chemistry, Northwestern University. John Wiley and Sons, Inc., New York City, 1941. xv + 332 pp. 117 figs. 15 × 23 cm. $4.50.

This book presents, as the title indicates, and the author states, "a detailed review and discussion of the glass electrode, of its limitations and difficulties, of its methods and applications, and of its mechanism and theory."

The first chapter is devoted to a brief electrochemical introduction. Sörensen's definition of pH as the negative logarithm of the hydrogen ion concentration is given, although today it has only historic interest. In the following chapter mention is made of "theoretical pH" and "true pH." From a pedagogical point of view this is somewhat confusing, and it is unfortunate that the author leaves the discussion of the significance of pH for the closing chapter of the book. The author is, of course, fully aware of the fact that pH is not a logarithmic measure of the hydrogen ion concentration, nor even of hydrogen ion activity. This he states clearly on page 303: "The pH function is not one which lends itself to thermodynamic definition in terms of the composition and concentration of the solution; it can only be defined in terms of electromotive force." Thus, the real character of the villain, pH, is not fully revealed until the last act. Many readers of this book, particularly students, may therefore retain quite erroneous notions as to just what it is that the glass electrode measures.

One of the closing chapters deals with the theory of the glass electrode. Here the author naturally presents chiefly his own ideas on the subject, to which this reviewer cannot entirely subscribe.

Much of the book which deals with glass electrode methods and applications succeeds in bringing together a considerable amount of useful information for the technician, who will be grateful to the author for this praiseworthy compilation.

The printing is good, with few typographical errors, and the book is well indexed. An appendix, containing some pertinent data and a table of logarithms, is included.

THEODORE SHEDLOVSKY

THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH
NEW YORK CITY

TRATADO DE QUÍMICA ORGÁNICA (Treatise on Organic Chemistry). Volume II, Part I. *Enrique V. Zappi*, Professor of Organic Chemistry at the Universities of Buenos Aires and La Plata, Member of the Academy of Sciences of Buenos Aires. First Edition. Librería y Editorial "El Ateneo," Buenos Aires, Argentina, 1941. xvi + 520 pp. 10 figs. 15.5 × 23.5 cm.

The author has planned to collect in this treatise the lectures delivered by him in his courses at the Universities of Buenos Aires and La Plata; it will consist of two volumes, each one of them further divided into two parts. The first volume will deal with the aliphatic compounds, while for the second are reserved the aromatic, cyclic, and heterocyclic compounds, and natural substances.

This book corresponds to the first part of the second volume, and is the first to appear. Its 495 pages are divided into thirteen chapters which, in general, deal with the following topics: constitution of benzene; aromatic hydrocarbons and their halogen, nitro, and sulfur derivatives; aromatic substitution and orientation; polynuclear hydrocarbons; amines; diazo compounds and diazonium salts; aromatic compounds of the metals and nonmetals; phenols and derivatives; quinones; and dyes.

The work is addressed to the students, and since the author is rightly convinced that organic chemistry "has to be understood and not memorized" his purpose is twofold: "the exposition of the facts of organic chemistry, and the presentation of the different theories which have been formulated for their explanation."

The author has succeeded in his attempt to make an advanced and at the same time didactic presentation of the field of organic chemistry. The exposition is modern and clear, and good use is made of recent developments and theories. The ideas of Lapworth, Robinson, and other modern theorists are clearly presented, and topics such as the problem of the constitution of benzene, aromatic substitution and orientation, and a few rearrangements are well developed and keep in view the didactic character primarily intended for the book. Only a very brief reference is made to the problem of resonance, but other topics (such as that of iodonium compounds) which have not as yet found their way into the average textbook are included in this one.

Proofs of constitution and structural formulas are abundant and well arranged. No references to the original literature are made, although, in a book of this scope, the student desiring to pursue a subject further would appreciate reference to articles of a general character. Brief biographical notes on outstanding chemists are scattered as footnotes. The form of the book and the printing are good, and the reviewer has discovered very few typographical errors. The word *hidrato* is loosely used to mean *hidróxido* (pages 8, 212).

One is eager to see the three other parts of the book and the way in which the author gives unity to the treatise. The prospects are excellent and no doubt the present book will be very much welcomed by both professors and students of organic chemistry in Spanish-speaking countries, where it will fill a gap long felt. The reviewer hopes, though, that the usefulness of the book will not be limited to the above-mentioned countries. For those interested in learning chemical Spanish, here is a first-class book.

J. GÓMEZ-IBÁÑEZ

CORNELL UNIVERSITY
ITHACA, NEW YORK

QUALITATIVE ANALYSIS. *H. V. Anderson*, B.Ch.E., M.S., Professor of Chemistry, Lehigh University, and *T. H. Hazlehurst*, A.B., Ph.D., Associate Professor of Chemistry, Lehigh University. Third Revised Edition. Prentice-Hall, Inc., New York City, 1941. xi + 266 pp. 14 figs. 15 × 23 cm. Trade, $3.70; School, $2.75.

In the preface the reasons justifying the publication of this revised edition are stated. Changes have been made in the grouping and arrangement of theoretical material. The discussion of acid-base and oxidation-reduction reactions has been expanded and their analogy to each other has been shown. Directions have been included for carrying out the laboratory work on a semimicro scale. Ionic equations have been written for ionic reactions. More questions and problems appear at the end of each chapter. Generally, the present text carries out better the principal objective, as stated in the review of the previous edition [J. CHEM. EDUC., **15**, 150 (1938)].

It again seems unusual that such important subjects as complex ions, salt effect, adsorption, and co-precipitation are not discussed in greater detail. The obsolete point of view that strong electrolytes are less than 100 per cent ionized is still presented.

The only change in the laboratory procedure has been the addition of directions for carrying out the work on one-tenth of the macro scale. This seems to be too large a proportion for the usually accepted semimicro work. The absence of better up-to-date methods for some of the analyses, as pointed out in the review of the previous edition, is again noticed.

The size of the book has been increased in both dimensions, the printing is better, and very few typographical errors are evident.

LEO LEHRMAN

THE CITY COLLEGE OF NEW YORK
NEW YORK CITY

DIFFUSION IN AND THROUGH SOLIDS. *Richard M. Barrer*, D.Sc. (N.Z.), Ph.D. (Cantab.), F.I.C., Head of the Chemistry Department, The Technical College, Bradford; formerly Research Fellow, Clare College, Cambridge. University Press, Cambridge, England; The Macmillan Company, New York City, 1941. xiii + 464 pp. 158 figs. 13.5 × 21.5 cm. $6.50.

As the author points out in the preface, "There are in general two states of flow by diffusion—the so-called stationary and non-stationary states. From the former one derives the *permeability constant* (quantity transferred per unit time per unit area of unit thickness under a standard concentration or pressure difference) and from the latter the diffusion constant." Denoting the latter by D, and the concentration gradient by dc/dx, the permeability, P, is given by the relation,

$$P = D(dc/dx)$$

The volume gives a very comprehensive survey of numerical values of P and D and experimental methods for their determination, for a large number of phenomena. A brief review of the contents of the different chapters shows the range of phenomena which are discussed in the volume.

In Chapter I are given a number of solutions of the diffusion equation,

$$\partial c/\partial t = D(\partial^2/\partial x^2)$$

which correspond to a variety of experimental conditions. "The solutions are as explicit as possible, so that they may be employed at once, or with the aid of tables of Gauss or Bessel functions."

Chapter II deals with "Stationary and Non-Stationary States of Molecular Flow in Capillary Systems." Different sections discuss molecular effusion, Knudsen flow, Poiseuille flow, turbulent flow, and orifice flow. The appropriate mathematical relations are given as well as experimental illustrations of their application. The flow of gases through porous plates and refractories as well as the separation of gas mixtures and isotopes by the methods of Hertz and those of Clusius and Dickel (thermodiffusion), are discussed in a very informative manner.

Chapter III is entitled "Gas Flow in and through Crystals and Glasses" and contains a detailed discussion of the permeability of glasses and the flow through ionic crystals such as rock salt.

Chapters IV and V deal with the solution of gases in metals and alloys, the permeability of metals to gases, and the diffusion constants of various elements in metals. In this section there are discussed such topics as the flow of nascent hydrogen through metals, the degassing of metals, and diffusion and absorption of gases in finely divided metals.

Chapter VI, on "Diffusion of Ions in Ionic Crystals, and the Interdiffusion of Metals," gives a review of data such as no other text has attempted to correlate and summarize. Special attention should be drawn to a table of diffusion constants according to the equation,

$$D = D_0 \text{ exponential } (-E/RT),$$

which is given on page 275, and to a tabulation of "Expressions for the diffusion constant and the ionic conductivity in crystals," page 305.

The titles of the remaining chapters are as follows: VII, Structure-sensitive Diffusion; VIII, Migration in the Surface Layer of Solids; IX, Permeation, Solution, and Diffusion of Gases in Organic Solids; X, Permeation of Vapors through, and Diffusion in, Organic Solids.

At the end of each chapter there is given a comprehensive list of references.

The author has rendered an extremely useful service for those interested in all types of diffusion phenomena, and the excellent presentation of experimental methods and data should prove invaluable to all investigators in this field. The only feature for which the printed volume may be criticized is with respect to the poor paper used in the printing—undoubtedly a result of present conditions in England.

SAUL DUSHMAN

RESEARCH LABORATORY
GENERAL ELECTRIC COMPANY
SCHENECTADY, NEW YORK

MEDICAL MANUAL OF CHEMICAL WARFARE. Reprinted by Permission of the Controller of His Britannic Majesty's Stationery Office. First American Edition. Chemical Publishing Co., Inc., Brooklyn, N. Y., 1941. 104 + 15 pp. 10 plates. 13.5 × 21.5 cm. $2.50.

In these times of uncertainty as to the part which chemical warfare will play in the present conflict this little book, from a British source, bears witness that the British, at least, have not lost sight of the enormous possibilities.

The various war gases are described in an introductory chapter and their tactical uses explained. By way of prediction it is proposed that:

"In view of the efficiency of the modern respirator, the ease with which it can be adjusted, and the knowledge of chemical warfare instilled into troops in their anti-gas training, it is probable that the old wartime lethal agents, such as chlorine or phosgene, will be less extensively used in a future war against enemies in the field. It is with mustard gas, however, that novelty in use is to be anticipated."

It is not surprising, therefore, that in the more detailed discussion considerable space is given to the properties, use, and effects of mustard gas and its close relative, Lewisite. Following are briefer accounts of lung-irritant gases (chlorine, phosgene, etc.), paralysant gases (HCN, H_2S), lachrymators and nasal irritants, and dangerous gases which may be met incidentally, such as CO, NO_2, and smokes. All these are discussed from a thoroughly practical standpoint, with emphasis on protection and treatment.

There is an excellent tabular summary of gases and their properties, a short chapter on protective shelters, pointers on first aid treatment, and a brief "atlas of gas poisoning," with illustrations of the symptomatic effects upon lungs, eyes, skin, and internal organs produced by mustard and phosgene.

AN INTRODUCTION TO ORGANIC CHEMISTRY. *Roger J. Williams*, Ph.D., D.Sc., Professor of Chemistry, University of Texas. Fourth Edition. D. Van Nostrand Company, Inc., New York City, 1941. xiii + 628 pp. 13 figs. 13.5 × 21.5 cm. $4.00.

The first edition of this text appeared in 1927. By the time a text reaches its fourth edition one is apt to lose sight of the contemporary scene at the time of the first edition. Briefly, it may be stated that in 1927 the time was ripe for the refreshing and original approach which Williams used. It is a matter of record that the first edition was eminently successful, and that succeeding editions have maintained the original high standard.

This fourth edition follows the general pattern of its predecessors, but there is a new chapter dealing with aliphatic halogen compounds. Noteworthy revisions may be found also in the sections dealing with petroleum, ketones, synthetic glycerol, synthetic rubber, Diels-Alder synthesis, allophanic acid and hydantoin, morphine, sulfa drugs, and the chapter on biochemical applications. The author continues to give emphasis to the centroid structure for aromatic and heterocyclic rings. Many of the chapters have had little or no alteration.

Nomenclature is good generally, but one could wish for more careful treatment in the matter of spaces and hyphens. Thus terms such as phenyl hydrazine, hexaphenyl ethane, vinyl acetylene, trimethyl carbinol, 2-chloro 1,3 butadiene, etc., occur too frequently. The 9,10-bridged formula for anthracene is retained also, in spite of the evidence against it. These are the most serious errors that came to the reviewer's notice. As in previous editions, the book sets a high standard for appearance, discriminating choice of subject matter, and clarity of presentation.

CHARLES D. HURD

NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS

FUNDAMENTALS OF PHYSICAL SCIENCE. AN INTRODUCTION TO THE PHYSICAL SCIENCES. *Konrad Bates Krauskopf*, Assistant Professor of Geology, Stanford University. First Edition. McGraw-Hill Book Company, Inc., New York City and London, 1941. x + 660 pp. 328 figs. 15 × 23 cm. $3.50.

This book aims to provide material adequate for the needs of the college student who wishes to understand the fundamental facts and methods of physical science which contribute to life in our modern world.

The author has organized the material under six major subdivisions: The Solar System, Matter and Energy, The Structure of Matter, Fundamental Processes, The Biography of the Earth, and Stars and Galaxies. In the first we find the fundamental laws of mechanics; in the second energy, kinetic theory, and elementary chemical concepts; in the third the newer concepts of matter, including subatomic chemistry; in the fourth material found in chemical texts; in the fifth selected material from the field of geology; and in the sixth sun, stars, and nebulae, ending with brief mention of such topics as relativity, fourth dimension, and gravitation under the general heading of Frontiers of Physical Science. Each subdivision closes with a well-selected list of suggested readings.

While the author states in his preface "the book is designed to be adaptable to courses of different lengths," which means omission of some parts, a review of the work convinces one that the student or reader will be best served when it is possible to read consecutively the whole text.

It is the opinion of the reviewer that students who spend one year in study with this text as a guide will have had a very profitable experience. The author has so courageously selected his material from such extensive fields that one hesitates to criticize minor defects which a specialist in a particular field might point out.

The publishers have done their share in making the printed and illustrative material attractive to the reader.

CLIFFORD D. CARPENTER

COLUMBIA UNIVERSITY
NEW YORK CITY

THE SECOND YEARBOOK OF RESEARCH AND STATISTICAL METHODOLOGY. *Oscar Krisen Buros*, Editor. The Gryphon Press, Highland Park, New Jersey, 1941. xx + 383 pp. 19 × 27 cm. $5.00.

This is the second compilation of excerpts from reviews of books whose subject matter is statistics, including its application to various fields and topics closely related. There are 1652 selections from 283 journals. The books accompanied by criticisms are 359 in number, arranged in alphabetical order of the authors' names. The following indexes serve as additional aid to locate information: (*a*) coöperating journals, (*b*) authors, (*c*) classified index of books, (*d*) titles, (*e*) periodical directory and index, (*f*) publisher's directory and index.

The compiler states several objectives: to show inadequacy of textbook presentation of statistics; to help the reader select textbooks; to assist advanced students to keep abreast of modern developments; to stimulate students to investigate books on statistical methods in a variety of fields; to note differences of opinion in evaluation; to observe extension of statistical method; to discourage writing of books by incompetent persons; to make available provocative statements formerly hidden; to stimulate good book reviews and to encourage selection of good reviewers by editors.

All this is decidedly advantageous to the statistician and to those investigators who use these methods frequently. If the chemist cares to inspect a comprehensive list of this type of book in order to ascertain its usefulness, here it is. The wider application of statistical methods may justify more attention. However, most of the books reviewed have no direct interest to the chemist, be he teacher or research worker. Since chemical literature is exceptionally well organized, all new books of definite interest are already conveniently listed in the very complete abstract journals.

The yearbook seems likely to be a very satisfactory reference book for a general library but would be used by the chemist only if some special case might warrant his investigation of statistical methodology to interpret his experimental results. Its limited use in the chemical field is not due to a weakness in the book but rather because few chemists use statistical methods.

VIRGINIA BARTOW

UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

HANDBOOK OF CHEMISTRY. Compiled and edited by *Norbert Adolph Lange*, Ph.D., Lecturer in Organic Chemistry at Cleveland College of Western Reserve University, assisted by *Gordon M. Forker*, B.S. (Chem. Eng.), Harshaw Chemical Company, Cleveland. With AN APPENDIX OF MATHEMATICAL TABLES AND FORMULAS by *Richard Stevens Burington*, Ph.D., Associate Professor of Mathematics at Case School of Applied Science. Fourth Edition Revised and Enlarged. Handbook Publishers, Inc., Sandusky, Ohio, 1941. xx + 1603 pp. Appendix, 271 pp. Index, 35 pp. 13 × 19.6 cm. $6.00.

The fourth edition of this standard reference work contains the following new tables: Synthetic Rubbers, Correction of the Boiling Point for Pressure, Calculation of the Boiling Point of Organic Compounds, Qualitative Spectrographic Analysis, Sensitive Lines of the Elements, Hammond's Cuprous Oxide and Copper Equivalents of Sugars, Conversion of Specific Gravity to Density, Azeotropic Mixtures, Tank and Pipe Capacities, Logarithms of Factorial *n*. Factorials, Binomial Coefficients. The following tables have been extended or completely rewritten: Description of the Elements, Changes in Atomic Weights from 1894 to 1941, Physical Constants of Alkaloids, Physical Constants of Glucosides, Physical and Chemical Properties of Resins, Calculations of Refractive Index, Electrometric Determination of Hydrogen Ion Concentration, Laboratory Solutions, Gravimetric Factors and Their Logarithms, Molar Elevation of the Boiling Point, Phenol Coefficients of Germicides and Antiseptics, Photographic Formulas, Probable Values of the Physical Constants, Table of Integrals, Squares, Cubes, Square Roots, and Cube Roots. The additions and extensions have increased the size of the volume by 85 pages.